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**Final Record of Decision for the
General Services Area Operable Unit
Lawrence Livermore National
Laboratory Site 300**

January 1997



Environmental Protection Department
Environmental Restoration Program and Division

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Acronyms and Abbreviations

Acronyms and Abbreviations

For the convenience of the reader, a reference list defining acronyms and abbreviations used throughout this document is presented after the Tables.

1. Declaration

1.1. Site Name and Location

The site described in this Record of Decision (ROD) is known as the General Services Area (GSA) operable unit (OU) located at Lawrence Livermore National Laboratory (LLNL) Site 300, Tracy, California. This OU is designated as OU-1 in the Site 300 Federal Facility Agreement (FFA) signed in June 1992.

1.2. Statement of Basis and Purpose

This decision document presents the selected remedial action for the GSA OU at LLNL Site 300. This remedial action was developed in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and, to the extent practicable, the National Contingency Plan (NCP). This decision is based on the Administrative Record for this OU. The State of California Department of Toxic Substances Control (DTSC), Central Valley Regional Water Quality Control Board (CVRWQCB), and the U.S. Environmental Protection Agency (EPA) Region IX concur with the selected remedy.

1.3. Assessment of the Site

Based on the baseline risk assessment, actual or threatened releases of hazardous substances at this OU, if not addressed by implementing the response actions selected in this ROD, may present an imminent and substantial endangerment to public health and welfare, or the environment.

1.4. Description of the Selected Remedy

In June 1992, a FFA for the LLNL Site 300 Experimental Test Facility was signed by the regulatory agencies (U.S. EPA Region IX, DTSC, CVRWQCB) and the landowner (U.S. Department of Energy [DOE]). The FFA defines seven OUs and designates the GSA OU as OU-1. The GSA OU is located in the southeastern portion of Site 300 and was established to address soil and ground water contamination in the subsurface immediately beneath and approximately 2,300 ft downgradient of the GSA facilities. Currently, a stream-lined CERCLA process is being adopted for Site 300 cleanup. This process will not affect the GSA OU, which will proceed on the current FFA schedule.

Remedial actions for the GSA OU primarily target trichloroethylene (TCE) and other volatile organic compounds (VOCs) in ground water and soil beneath the GSA. The risks associated with subsurface contamination at the GSA OU are: 1) potential ingestion of ground water containing VOCs, and 2) onsite worker inhalation exposure to TCE volatilizing from subsurface soil (0.5–12.0 ft) to indoor air within Building 875.

Three remedial alternatives for the GSA OU were presented in the Final General Services Area Feasibility Study (Rueth and Berry, 1995). These remedial alternatives were evaluated by the supervising Federal and State regulatory agencies and presented to the public. DOE and the regulatory agencies, the U.S. EPA, and the State of California DTSC and CVRWQCB agreed that Alternative 3b provides the most effective means of remediating VOCs in soil and ground water to levels protective of human health and the environment. Alternative 3b is presented as the selected remedy for the GSA OU. The major components of the selected remedy include:

- Monitoring throughout the predicted 55 years of remediation, plus five years of post-remediation monitoring.
- Contingency point-of-use (POU) treatment for existing offsite water-supply wells.
- Administrative controls to prevent human exposure by restricting access to or activities in contaminated areas, if necessary.
- Soil vapor extraction (SVE) and treatment in the central GSA dry well source area. SVE will be conducted to: 1) reduce VOC concentrations in soil vapor to levels protective of ground water, 2) remediate dense non-aqueous phase liquids (DNAPLs) in the soil, and 3) mitigate VOC inhalation risk inside Building 875.
- Dewatering of the shallow water-bearing zone in the vicinity of the Building 875 dry well release area to enhance the effectiveness of SVE by exposing a larger soil volume to vapor flow.
- Extraction and treatment of ground water in the GSA until drinking water standards (Maximum Contaminant Levels, or MCLs) are reached in both the regional and shallow aquifers. Modeling indicates ground water extraction will reduce ground water VOC concentrations in the eastern and central GSA to the remediation goal (MCLs) within 10 and 55 years, respectively.

The 1995 present-worth cost of the selected remedy is estimated to be approximately \$18.90 million. This estimate assumes: 1) 10 years of SVE, and 55 years of ground water extraction in the central GSA, 2) 10 years of ground water extraction in the eastern GSA debris burial trench area, and 3) 60 years of ground water monitoring. These time and cost estimates do not include the development, testing, or utilization of any future innovative technologies, which, if available, could be used to expedite cleanup and/or reduce long-term costs.

DOE and the regulatory agencies will jointly determine the scope and schedule of all required post-ROD documents and reports (up to the Final Remedial Design document), as well as schedules for implementing the selected remedy.

2. Decision Summary

2.1. Site Name, Location, and Description

Site 300, a DOE-owned experimental test facility operated by the University of California, is located in the southeastern Altamont Hills of the Diablo Range, about 17 mi east-southeast of Livermore and 8.5 mi southwest of Tracy, California (Fig. 1). The site is bordered by cattle grazing land, a California Department of Fish and Game ecological preserve, an outdoor recreational facility, and a privately owned high explosives (HE) testing facility. For the purpose of this ROD, it is assumed that Site 300 will remain under the continued control of DOE for the foreseeable future.

The GSA OU is located in the southeastern part of Site 300, and was established to address soil and ground water contamination in the subsurface below the OU (Fig. 2).

2.2. Site History and Summary of Enforcement

Prior to the purchase of Site 300 land for development as a DOE experimental test facility in 1953, the GSA was used for cattle ranching and livestock grazing. Since the late 1950s, the GSA facilities have been used as administration offices and equipment fabrication and repair shops that support Site 300 activities. Site 300 was in operation prior to the enactment of the Resource Conservation and Recovery Act of 1976.

Undetermined quantities of solvents containing TCE, a suspected human carcinogen, and other VOCs were released to the ground as a result of past activities in the craft shops, equipment fabrication and repair facilities in the GSA, and are in the soil/rock and ground water in the area. Other chemical compounds commonly detected in soil/rock and ground water in the GSA include tetrachloroethylene (PCE), 1,2-dichloroethylene (DCE), 1,1-DCE, and freon compounds.

In 1982, DOE discovered contamination at the site and began an investigation under CVRWQCB guidance. All investigations of potential chemical contamination at Site 300 were conducted under the oversight of the CVRWQCB until August 1990, when Site 300 was placed on the National Priorities List. Since then, all investigations have been conducted in accordance with CERCLA under the guidance of three supervising regulatory agencies: the U.S. EPA Region IX, the CVRWQCB, and the DTSC. The DOE entered into a FFA with these agencies in June 1992.

In accordance with CERCLA requirements and the terms of the Site 300 FFA, DOE released the Final Site-Wide Remedial Investigation (SWRI) report (Webster-Scholten, 1994), the Final General Services Area Operable Unit Feasibility Study (FS) (Rueth and Berry, 1995) and the Proposed Plan for Remediation of the Lawrence Livermore National Laboratory Site 300 General Services Area (U.S. DOE/LLNL, 1996). The SWRI documented environmental investigations that occurred at Site 300 since 1982, and characterized the extent of VOCs in the subsurface and the Site 300 hydrogeology. The GSA FS developed and evaluated alternatives for remedial action at the GSA. The SWRI and the FS form the basis for selecting technologies

to remediate the GSA OU. The Proposed Plan for remediation of the GSA OU summarized site conditions and remedial alternatives, and presented the preferred remedy.

CERCLA Removal Actions were initiated in the eastern and central GSA in 1991 and 1993, respectively. To date, 35,387 grams (79 lb) of VOCs have been removed from the GSA through ground water and soil vapor extraction as part of these Removal Actions.

2.3. Highlights of Community Participation

The SWRI and the FS for the GSA OU were made available to the public in April 1994 and October 1995, respectively. The Proposed Plan was released to the public in March 1996. This ROD presents the selected remedial action for the GSA OU. All documents were prepared in compliance with CERCLA as amended by SARA. The decision for this site is based on the Administrative Record, which is available at the Information Repository at the LLNL Visitors Center and the Tracy Public Library.

A public review and comment period on the preferred remedial alternative began April 10, 1996, and ended May 10, 1996. Interested members of the public were invited to review all documents and comment on the considered remedial alternatives by writing to the Site 300 Remedial Project Manager or by attending a public meeting on April 24, 1996, at the Tracy Inn in Tracy, California. At this meeting, representatives from DOE, University of California, U.S. EPA, and the State of California discussed the proposed remediation plan and addressed public concerns and questions. Questions and comments from the public are presented and addressed in the Responsiveness Summary of this ROD.

2.4. Scope and Role of the GSA OU

The Site 300 FFA defines the following seven OUs at Site 300:

- OU-1, GSA.
- OU-2, Building 834.
- OU-3, Pit 6.
- OU-4, HE Process Area Building 815.
- OU-5, Building 850/Pits 3 and 5.
- OU-6, Building 854.
- OU-7, Building 832 Canyon.
- OU-8, Site 300 Monitoring.

Investigations at the GSA OU address VOCs in soil/rock and ground water released to the environment as a result of past activities in the GSA craft shops, and equipment fabrication and repair facilities. The principal potential threats to human health and the environment are: 1) ingestion of VOCs in ground water, and 2) exposure to VOC vapors volatilizing from shallow soil into Building 875.

This ROD addresses both the potential human health ingestion risk posed by VOCs in ground water, as well as the inhalation risk posed by VOCs in the vadose zone at the GSA OU. The purpose of the selected remedy is to protect human health and the environment by reducing VOC concentrations in soil vapor and ground water and controlling VOC migration.

2.5. Site Characteristics

Since environmental investigations began at the GSA in 1982, 75 exploratory boreholes have been drilled and 98 ground water monitor wells have been completed. Details of the geology and hydrogeology of the GSA OU, as well as environmental investigations conducted in this OU are presented in Chapter 14 of the Site 300 SWRI. Three water-bearing zones or hydrogeologic units have been identified (Fig. 3):

- **Qt-Tnsc₁ Hydrogeologic Unit:** This shallow water-bearing zone occurs beneath the central GSA portion of the OU and is composed of stratigraphic units Qt (terrace alluvium), Tnbs₂ (Neroly Formation-Upper Blue Sandstone), and Tnsc₁ (Neroly Formation-Siltstone/Claystone). Depending on topography, depth to water is approximately 10 to 20 ft beneath the ground surface. As a result of past releases, this shallow aquifer contains TCE and other VOCs. The VOC plume in this shallow aquifer is separated from the regional aquifer by a 60- to 80-ft thick aquitard (Tnsc₁) in most of the central GSA. Ground water data indicate that the VOC plume in the shallow aquifer has not affected the regional aquifer in this area. Ground water in this shallow aquifer flows south-southeast with an estimated flow velocity of 0.09 to 3 ft/day.
- **Tnbs₁ Hydrogeologic Unit (Regional Aquifer):** The regional aquifer occurs in the lower Neroly Formation (Tnbs₁). This aquifer is encountered 35 to 145 ft below the ground surface under confined to semi-confined conditions in the central GSA. Ground water flow in this unit is to the south-southeast at a flow velocity of 0.3 ft/day.
- **Qal-Tmss Hydrogeologic Unit:** This hydrogeologic unit is composed of the stratigraphic units: Qal (alluvium), Tnsc₁, Tnbs₁, and Tmss (Cierbo Formation). For the most part, the Tnsc₁ aquitard is absent in the eastern GSA, and the shallow water-bearing zone (Qal) is in hydraulic communication with the underlying regional aquifer (Tnbs₁). As a result, some contamination has migrated downward from the shallow-water bearing zone into the regional aquifer. Ground water flow in the alluvium (Qal) and shallow Tnbs₁ bedrock is eastward, turning north to follow the trend of the valley. Although the flow velocity is dependent on local hydraulic conductivity, the maximum flow velocity is estimated to be about 200 to 1,200 ft/yr.

2.5.1. Chemical Releases

Historical information and analytical data suggest that VOCs, in the dissolved form and/or as DNAPLs, were released to the ground in wastewater from the craft and repair shops, as

leaks/spills from solvent storage tanks or drums, and associated with debris buried in trenches in the eastern GSA in the 1960s and 1970s. These releases include:

- VOCs in rinse-, process-, and wash-water discharged to four dry wells from the central GSA craft and repair shops. Based on soil and ground water analytical data, the greatest VOC mass is concentrated in the vicinity of the Building 875 former dry wells.
- VOCs released to the ground from a decommissioned drum storage rack north of Building 875.
- VOCs in rinse water discharged from a steam cleaning/sink area east of Building 879.
- VOCs associated with craft shop debris buried in trenches in the eastern GSA.

The confirmed release sites for the central and eastern GSA are shown in Figures 4 and 5. The quantity of TCE released in these areas greatly exceeds that of other VOCs.

2.5.2. VOCs in Ground Water

TCE is the most prevalent VOC in ground water, typically comprising 85 to 95% of the total VOCs detected. Other VOCs that have been detected include PCE, 1,2-DCE, 1,1-DCE, 1,1,1-trichloroethane, acetone, benzene, bromodichloromethane, chloroform, ethylbenzene, Freon 113, toluene, and xylenes (total isomers) (Table 1).

Detected concentrations of ethylbenzene, toluene, and xylene have decreased over time. Toluene, ethylbenzene, and xylenes have not been detected in ground water from any GSA wells in over 2.5 years. The last detections of these compounds occurred in 1994 when toluene was detected in well W-875-02 at a concentration of 0.5 µg/L and xylene was detected in well W-7N at a concentration of 0.96 µg/L. No toluene, ethylbenzene, or xylenes have been detected in any other GSA wells for 3.5 years or more. Therefore, these constituents are no longer considered contaminants of concern. The CVRWQCB believes that it is appropriate to continue to monitor for these constituents, but at a reduced frequency. The extent and frequency of monitoring for these constituents will be addressed in the Remedial Design document.

The highest ground water VOC concentrations in the central GSA have been detected in the vicinity of former dry well pad south of Building 875 (Figs. 4 and 6). TCE has been detected in ground water in concentrations up to 240,000 micrograms per liter (µg/L) in a bailed ground water sample collected from well W-875-07 in March 1993. This concentration suggests that TCE is present as residual DNAPL in the subsurface. As of third quarter 1994, the maximum TCE concentration in ground water samples collected from the Building 875 dry well pad area was 10,000 µg/L in well W-7I (Fig. 6). In general, if a ground water VOC concentration is 1 to 10% of the solubility of that VOC in ground water, a DNAPL may be present. Because the aqueous solubility of TCE is 1,100,000 µg/L, TCE concentrations in the range of 11,000 to 110,000 µg/L or greater may indicate DNAPL. The only wells in the GSA where ground water sample data indicate the possible presence of DNAPLs (TCE concentrations > 11,000 µg/L) are wells W-875-07, -08, -09, -10, -11, -15, and W-7I. As shown in Figure 6, these wells are all located in the Building 875 dry well pad area in the central GSA. The source of DNAPLs in this area was the waste water disposed in the two former dry wells, 875-S1 and 875-S2, located south of Building 875 (Fig. 4). Based on soil sample data from boreholes drilled prior to installation of the dry well pad wells, the bulk of TCE contamination in the dry well pad area is concentrated at

a depth of 20 to 35 ft near the contact between the Tnbs₂ water-bearing zone and the underlying Tnsc₁ confining layer. These data support a DNAPL-type scenario where TCE, which is denser than water, would tend to sink to the lowest point possible in a water-bearing unit, such as the contact between the water-bearing zone and an underlying confining layer that prevents the further downward migration of contaminants.

No other wells in the GSA have contained VOCs in ground water in concentrations indicative of DNAPLs, including wells located at other source areas and the two wells (W-7F and W-875-03) located within 50 to 75 ft of the dry well pad. We have therefore concluded that the DNAPLs are confined to the Building 875 dry well pad area in the central GSA.

As shown in Figure 6, a VOC ground water plume in the Qt-Tnsc₁ shallow aquifer extends from the Building 875 dry well pad and Building 872 and Building 873 dry wells into the Corral Hollow Creek alluvium. There is a smaller ground water plume with significantly lower VOC concentrations to the north associated with the drum storage rack and steam cleaning release sites. Based on ground water data collected from the Tnbs₁ regional aquifer, the VOC plumes appear to be confined to the Qt-Tnsc₁ hydrogeologic unit in this area, where the Tnsc₁ confining layer prevents the downward migration of contaminants. West of the sewage treatment pond, TCE has been detected in ground water in the regional aquifer (Fig. 7) where the Tnsc₁ confining layer is absent. The low TCE concentrations have generally been decreasing in the regional aquifer in this area since 1990.

In the eastern GSA, the highest VOC concentrations in ground water occur in the vicinity of the debris burial trench area (Fig. 8). TCE has been detected in ground water in concentrations up to 74 µg/L in this area. A VOC ground water plume extends eastward from the debris burial trench area and has migrated northward in the Corral Hollow alluvium. The plume with total VOC concentrations exceeding 5 µg/L currently extends approximately 550 ft from the debris burial trench release area. TCE has also been detected at low concentrations in ground water in the regional aquifer in the vicinity of the debris burial trenches (Fig. 9). TCE in the regional aquifer in this area is generally limited to portions of the regional aquifer which directly underlie the contaminated shallow water-bearing zone. The maximum VOC concentrations in ground water as of fourth quarter 1995 were 20 µg/L in the shallow water-bearing zone and 19 µg/L in the regional aquifer.

Further details on the extent of VOCs in ground water in the GSA can be found in Section 14-4.5, Chapter 14 of the Site 300 SWRI (Webster-Scholten, 1994), and Section 1.4.7 of the GSA FS (Rueth and Berry, 1995).

2.5.3. VOCs in Soil/Rock

The highest TCE concentrations in soil/rock (up to 360 milligrams per kilogram [mg/kg]) in the central GSA were detected in the vicinity of the Building 875 former dry wells 875-S1 and 875-S2 at a depth of 20 to 35 ft near the contact between the Tnbs₂ water-bearing zone and the underlying Tnsc₁ confining layer. Also, low concentrations of VOCs were detected in soil/rock samples collected from boreholes in the vicinity of the other four confirmed release sites in the central GSA: the decommissioned solvent drum rack, dry wells 872-S and 873-S, and the Building 879 steam-cleaning facility. VOC concentrations ranged from 0.0002 mg/kg to 0.9 mg/kg in these samples collected in 1989.

TCE, PCE and 1,2-DCE have been detected in concentrations up to 0.19 mg/kg in borehole soil samples collected in 1989 in the vicinity of the debris burial trenches in the eastern GSA.

Further details on the extent of VOCs in soil/rock in the GSA are described in Section 14-4.3, Chapter 14 of the Site 300 SWRI (Webster-Scholten, 1994) and Section 1.4.6 of the GSA FS (Rueth and Berry, 1995).

2.5.4. VOCs in Soil Vapor

Extensive soil vapor surveys, including both active and passive techniques, were conducted between 1988 and 1994 to: 1) assist in the identification of release sites, 2) determine the extent of VOC contamination, and 3) monitor the progress of soil vapor remediation efforts.

Further details on the extent of VOCs in soil vapor in the GSA can be found in Section 14-4.2, Chapter 14 of the Site 300 SWRI (Webster-Scholten, 1994), and Section 1.4.3 of the GSA FS (Rueth and Berry, 1995).

2.6. Risk Assessment

The baseline risk assessment provides the basis for taking action and identifies the potential exposure pathways that need to be addressed by the remedial action. It serves as the baseline to indicate what potential risks might exist if no action were taken at the site. This section of the ROD reports the results of the baseline risk assessment conducted for this site. Additional details may be found in Chapter 6 of the Site 300 SWRI (Webster-Scholten, 1994), and Section 1.6 of the GSA FS (Rueth and Berry, 1995).

The baseline risk assessment evaluated potential present and future public health and ecological risks associated with environmental contamination in the GSA OU, using the assumption that no cleanup or remediation activities would take place at the site. Selection of a specific remediation strategy is based in part on the extent to which it can reduce potential public health and ecological risks.

The baseline risk assessment presented in the SWRI consists of six components:

- Identification of chemicals of potential concern.
- Identification of the contaminated environmental media.
- Estimation of potential exposure-point concentrations of contaminants.
- Human exposure and dose assessment.
- Toxicity assessment.
- Risk characterization.

Each of these components are summarized in the following sections. Additional details are available in the Site 300 SWRI and in the GSA FS.

2.6.1. Identification of Chemicals of Potential Concern

Tables 1 through 4 present the chemicals of potential concern identified in the GSA OU. Details of the methodology used to identify these contaminants are described in the Site 300 SWRI (Webster-Scholten, 1994).

2.6.2. Identification of Contaminated Environmental Media

Based on the assessment of the nature and extent of contamination obtained during site characterization, contaminants of potential concern were identified in different environmental media in the GSA OU: ground water, surface soil, subsurface soil, and soil vapor (Tables 1 through 4, respectively). The 95% upper confidence limit (UCL) of the mean concentration and exposure-point concentrations of each contaminant are listed in Table 5.

2.6.3. Estimates of Potential Exposure-Point Concentrations

Conceptual models were developed to identify the probable migration processes and routes of the chemicals of concern from release sites and source media in the GSA OU to selected potential exposure points. The conceptual models provided the basis for selection of the quantitative models used to generate estimates of contaminant release rates and potential exposure-point concentrations. The exposure-point concentrations were used to estimate the magnitude of potential exposure to contaminants in the baseline risk assessment. The release areas, migration processes, and exposure points identified in the GSA OU are given in Table 5. In addition, this table lists the mathematical models used to estimate contaminant migration rates and the calculated exposure-point concentrations for the chemicals of concern in each environmental medium.

Direct measurements of VOC soil flux were obtained in the GSA that were used in a mathematical model to estimate exposure-point concentrations of contaminants in the atmosphere when VOCs volatilize from subsurface soil in the vicinity of three exposure locations in the GSA OU: 1) the Building 875 dry well area, 2) the central GSA, and 3) the eastern GSA. A mathematical model was applied, using subsurface soil (0.5 to 12.0 ft) VOC concentrations in the vicinity of the Building 875 dry well pad, to estimate the potential exposure-point concentrations of contaminants in indoor air of Building 875 when VOCs volatilize from subsurface soil underneath the building and diffuse into the building. Measurements of actual VOC concentrations inside Building 875 were not conducted or used in the estimate of exposure-point concentrations in indoor air as the work activities which still occur in Building 875 involve the use of VOC-containing solvents. Therefore, it would be difficult, if not impossible to distinguish between VOC vapors migrating from the subsurface through the concrete floor and those present in indoor air as a result of current work activities utilizing solvents. As a result, we took a health conservative approach and utilized soil sample data from the Building 875 dry well pad approximately 35 ft from the building to calculate exposure-point concentrations inside Building 875.

In addition, estimates were made of the concentrations of surface soil (≤ 0.5 ft) contaminants that are bound to resuspended particles throughout the OU. The 95% UCLs of the mean contaminant concentration in the surface soil, and site-specific data on total resuspended

particulates were used to estimate the concentration of surface soil contaminants bound to resuspended particles throughout the OU. For direct dermal contact and incidental ingestion, the exposure-point concentrations of contaminants in surface soil are the same as the 95% UCLs of the mean concentration of the chemicals.

The fate and transport of VOCs in ground water were considered for both the central and eastern GSA, as well as a combined central and eastern GSA plume. For the central GSA, exposure-point concentrations were estimated at the site boundary and then modeling was used to estimate exposure-point concentrations at the California Department of Forestry water-supply well, CDF-1, located approximately 300 ft southeast of the Site 300 boundary. For the eastern GSA, exposure-point concentrations were estimated for a theoretical well at the site boundary and for two plumes commingling at well CDF-1; these concentrations were modeled to downgradient water-supply well SR-1 (Fig. 10).

2.6.4. Human Exposure and Dose Assessments

Exposure scenarios and pathway exposure factors (PEFs) used to assess the magnitude of potential human exposure and dose are described below.

2.6.4.1. Exposure Scenarios

The exposure scenarios used to evaluate potential adverse health effects associated with environmental contamination in the GSA OU were developed based on assumptions about present and future uses of the site and lands in the immediate vicinity.

Two principal scenarios were developed to evaluate potential human exposure to environmental contaminants in the GSA OU. The first of these scenarios pertains to adults working in the GSA OU. This scenario addresses potential health risks attributable to contaminants in subsurface soil and surface soil, where an adult on site (AOS) is presumed to work in the immediate vicinity of the contamination over their entire period of employment at the site (25 years). Subsurface soil contaminants can volatilize into air, where they may be inhaled by individuals who work in the vicinity of the contamination. Surface soil contaminants bound to resuspended soil particulates may also be inhaled by individuals in the course of work-related activities at the site. In addition, we evaluated AOS exposure as a consequence of dermal absorption and incidental ingestion of contaminants on surface soil.

The second scenario pertains to residential exposures (RES), which are associated with use of contaminated ground water from: 1) theoretical wells installed at the central and eastern GSA site boundaries, 2) well CDF-1, and 3) well SR-1. The identification and selection of exposure pathways related to residential use of contaminated ground water were based on the assumption that well water will be used to supply all domestic water needs, such as those associated with showering or bathing, cooking, dishwashing, and laundry. We also assumed that contaminated ground water will be used to irrigate home gardens, and will be supplied to dairy and beef cattle raised for domestic consumption. Accordingly, we evaluated potential residential exposure to contaminants in ground water at theoretical wells and existing wells CDF-1 and SR-1 due to: 1) direct ingestion of water, 2) inhalation of VOCs that volatilize from water to indoor air, 3) dermal absorption of contaminants while showering or bathing, 4) ingestion of fruits and vegetables grown using contaminated ground water, and 5) ingestion of meat and milk from

homegrown beef and dairy cattle supplied with contaminated ground water. For the purpose of the risk assessment, we assume residents could be exposed to contaminants in ground water for 30 years.

2.6.4.2. Pathway Exposure Factors

To estimate the magnitude of potential human exposure to contaminants in the GSA OU, we developed PEFs, which convert the exposure-point concentrations of contaminants into estimates of average contaminant intake over time (the chronic daily intake, or CDI). These PEFs are based on a series of reported and/or assumed parameters regarding current and potential land use patterns in and around the GSA OU, residential occupancy patterns, and length of employment. PEFs also account for a number of physiological and dietary factors such as the daily ingestion rates of water and homegrown fruits, vegetables, beef, and milk; daily breathing rate; and surface area of exposed skin.

Reference documents for PEF data that were used to evaluate potential adult onsite and residential exposure to contaminants and summary values are listed in Table 6.

2.6.5. Toxicity Assessment

For each location with environmental contamination, we began by identifying those chemicals of concern that are classified by the U.S. EPA (U.S. EPA, 1992a) or by the State of California EPA (1992) as carcinogens. This classification is based on data from epidemiological studies, animal bioassays, and *in vivo* and *in vitro* tests of genotoxicity.

2.6.5.1. Cancer Potency Factors

The Cancer Potency Factors (CPFs) used in our estimations of cancer risk were obtained from values published in either the Integrated Risk Information System (IRIS) (U.S. EPA, 1992b), the Health Effects Assessment Summary Tables (U.S. EPA, 1992a,c), or by the State of California, EPA (1992). CPFs for TCE and PCE were also provided by Region IX of the U.S. EPA (1993a). All CPFs were derived using versions of the linearized, multistage dose-response model (U.S. EPA, 1989a,b); generally, the dose- and tumor-incidence data used in the model are from animal bioassays. For contaminants of potential concern at Site 300, the exceptions are cadmium, benzene, and beryllium, where human tumor data are available. The model calculates the potential increased cancer risk, where increased risk is linearly related to dose for low-dose levels typical of environmental exposure. Use of animal bioassay data to predict human tumorigenic response assumes that animals are appropriate models of human carcinogenic response, and that the dose-response relationships observed in high-dose animal bioassays can be extrapolated linearly to the low doses generally associated with human exposure to environmental contaminants. When CPFs were available for a particular contaminant from both a U.S. EPA source and the State of California, the highest potency values were used.

Reference documents for CPFs (slope factors) used to calculate cancer risks in our evaluation are listed in Table 6.

2.6.5.2. Reference Dose

The reference doses (RfDs) used to evaluate potential noncarcinogenic adverse health effects were based, when possible, on long-term (i.e., chronic) exposures, and were derived by dividing an experimentally-determined no-observed-adverse-effect-level or lowest-observed-adverse-effect-level (each has units of mg/[kg • d]) by one or more uncertainty factors (U.S. EPA, 1992a,b,c). Each of these uncertainty factors has a value that ranges from 1 to 10 (U.S. EPA, 1992a,b,c). Pathway-specific RfDs were used, when available (U.S. EPA, 1992a,b,c; Cal-EPA, 1992), to calculate a corresponding Hazard Quotient (HQ). If pathway-specific RfDs were not available, the published RfDs (typically developed for oral exposures) were used to calculate an HQ for all exposure pathways.

Reference documents and reference doses used to calculate noncancer hazard indices in our evaluation are listed in Table 6.

2.6.6. Risk Characterization

The risk assessment was performed in accordance with Risk Assessment Guidance for Superfund (U.S. EPA, 1989a,b). Carcinogenic risks, an evaluation of potential noncarcinogenic exposure health hazards, and the additivity of response are described below.

2.6.6.1. Carcinogenic Risks

For carcinogens, we calculated the potential incremental cancer risk associated with long-term exposure to chemicals in surface soil, subsurface soil, and ground water. For each chemical at each exposure location, the total risk attributable to that chemical was estimated by multiplying each pathway-specific intake (e.g., the dose due to ingestion of water or to inhalation of contaminants that volatilize from water to indoor air) by the corresponding pathway-specific CPF. The products of each pathway-specific intake and pathway-specific CPF were summed to obtain the potential incremental cancer risk for a specific chemical. Parallel sets of calculations were completed for all chemicals at each exposure location, then values of chemical-specific risk from all chemicals were summed to yield an estimate of total incremental risk for exposures associated with a given location.

2.6.6.2. Evaluation of Hazard from Exposure to Chemicals that Cause Noncancer Health Effects

For chemicals of potential concern that are not classified as carcinogens, and for those carcinogens known to cause adverse health effects other than cancer, the potential for exposure to result in noncarcinogenic adverse health effects was evaluated by comparing the CDI with a RfD. When calculated for a single chemical, this comparison yields an HQ. For each chemical at each location, pathway-specific HQs were summed (where applicable) to obtain an HQ estimate for a given chemical. We then summed all HQs from all chemicals to yield a hazard index (HI) estimate for exposures associated with a given location.

2.6.6.3. Additivity of Response

In every location at or near the GSA OU where cancer risk and noncancer HQs were calculated, CDIs were estimated for exposures attributable to multiple pathways for each of several contaminants. As noted previously, the total potential cancer risk and/or total HI were estimated by summing risk or HQs for all contaminants at a given location, where each chemical-specific estimate of risk or hazard represents exposures from multiple pathways. Implicit in the summation of risk and hazard is the assumption that the effects of exposure to more than one chemical are additive. This simplifying assumption does not consider similarities or differences in target organ toxicity, mechanism(s) of action, or the possibility of synergistic or antagonistic effects of different chemicals in the mixture.

2.6.7. Summary of Human Health Baseline Risks and Hazards Associated with Contaminants

Estimated baseline risks and hazards for the GSA OU were evaluated for adults on site exposures and residential exposures, as well as additive potential risk. These are described below, followed by a brief discussion of uncertainty.

2.6.7.1. Adult Onsite Exposures

The AOS exposure scenario addresses potential health risk attributable to contaminants in soil, where an AOS is presumed to work in the immediate vicinity of the contamination over the entire period of employment at the site (25 years).

We evaluated potential AOS exposure to contamination by calculating the associated risk and hazard for two scenarios. The first of these scenarios pertains to potential AOS exposure to contaminated subsurface soil through inhalation of VOCs volatilizing from subsurface soil to air. The second scenario pertains to potential AOS exposure to contaminated surface soil from inhalation of resuspended particulates, dermal absorption of contaminants following direct contact with contaminated soil, and incidental ingestion.

Risk and hazard associated with AOS exposure to contaminated subsurface soil through inhalation of VOCs volatilizing from subsurface soil (0.5 to 12.0 ft) to ambient air was evaluated in the vicinity of three exposure locations in the GSA OU: 1) the Building 875 dry well area, 2) the central GSA, and 3) the eastern GSA. Individual potential excess lifetime cancer risks were 2×10^{-7} for the Building 875 area, 7×10^{-7} for the central GSA, and 2×10^{-7} for the eastern GSA. The estimated noncancer HIs were 6.2×10^{-3} for the Building 875 area, 1.2×10^{-3} for the central GSA, and 1.3×10^{-3} for the eastern GSA.

The potential excess lifetime cancer risk and noncancer HIs for the AOS exposure to contaminants volatilizing from subsurface soil to ambient air are within the acceptable range (cancer risk $< 10^{-6}$ and HI < 1) specified by the NCP (U.S. EPA, 1990a).

Risk and hazard were also evaluated for AOS inhalation exposure to VOCs volatilizing from contaminated subsurface soil underneath Building 875 and diffusing into the building. The exposure scenario for an AOS working inside Building 875 resulted in estimates of individual potential excess lifetime cancer risk (1×10^{-5}) and noncancer HI (3×10^{-1}). While the

noncancer HI for this scenario is within acceptable limits ($HI < 1$), the potential excess lifetime cancer risk is within the range (between 10^{-4} and 10^{-6}) where risk management measures are necessary.

The baseline evaluation of risk and hazard associated with AOS exposure to surface soil contaminants yielded estimates of individual excess lifetime cancer risk of 2×10^{-7} for inhalation of resuspended particulates and 2×10^{-10} for ingestion and dermal absorption of surface soil contaminants. The corresponding HIs are 5.6×10^{-5} for inhalation and 8.5×10^{-3} for ingestion and dermal absorption. The potential excess lifetime cancer risk and noncancer HIs for the AOS exposure to surface soil contaminants are within the acceptable range (cancer risk of $< 10^{-6}$ and $HI < 1$) specified by the NCP (U.S. EPA, 1990a).

Reference documents for calculations and estimates of potential cancer risk and hazard index and the results are summarized in Table 6.

2.6.7.2. Additive Risk and Hazard for Adults Onsite

Adults working outdoors in the GSA OU could be exposed simultaneously to contaminants in surface soil (by inhalation of resuspended particulates, and ingestion and dermal absorption of surface soil contaminants) as well as by inhalation of the VOCs that volatilize from subsurface soil. The vicinity of the central GSA was selected for our calculations of additive risk and HI associated with AOS exposures because our calculations indicated higher levels of cancer risk and HI for this location than for exposures associated with the Building 875 dry well area and the eastern GSA. Because the Building 875 dry well area, central GSA, and eastern GSA are separated by approximately 200 ft, we did not examine concurrent exposures to VOCs from the three sources.

Table 6 presents the potential additive individual excess lifetime cancer risk and HI estimates for AOS exposures in the GSA OU. The values given in Table 6 indicate an estimated total additive cancer risk of 9×10^{-7} and a total additive HI of 9.7×10^{-3} .

The potential additive individual excess cancer risk and additive noncancer HIs for the AOS exposure in the GSA OU are within the acceptable range (cancer risk $< 10^{-6}$ and $HI < 1$) specified by the NCP (U.S. EPA, 1990a).

2.6.7.3. Residential Exposures

Risk and hazard were evaluated for potential RES use of contaminated ground water at: 1) hypothetical wells located at the site boundary near the Building 875 dry wells and the eastern GSA debris burial trenches, and 2) at existing water-supply wells CDF-1 and SR-1.

We calculated the risk and hazard associated with potential RES use of contaminated ground water from a hypothetical water-supply well located at the site boundary nearest to the Building 875 dry wells. The individual excess lifetime cancer risk attributable to the potential use of ground water at this location is 7×10^{-2} , and the corresponding HI is 560. These values estimate that if ground water at the site boundary in the central GSA were to be used for residential purposes on a regular basis for 30 years, there would be an unacceptable incremental excess cancer risk and unacceptable noncancer health effects.

We also evaluated risk and hazard associated with potential residential use of contaminated ground water at the site boundary nearest to the eastern GSA debris burial trenches. The individual excess lifetime cancer risk attributable to the potential use of ground water at this location is 5×10^{-5} , and the corresponding HI is 5×10^{-1} . In addition, we calculated the risk and hazard associated with potential use of contaminated ground water at two offsite locations, wells CDF-1 and SR-1. The individual excess lifetime cancer risks attributable to the potential use of ground water at these locations are 1×10^{-5} and 2×10^{-5} , respectively. The corresponding HIs are 1.4×10^{-1} and 1.6×10^{-1} . While the noncancer HI for these scenarios are within acceptable limits (HI <1), the potential excess lifetime cancer risk is within the range (between 10^{-4} and 10^{-6}) where risk management measures are necessary (U.S. EPA, 1990a).

Reference documents for calculations and estimates of potential cancer risk and hazard index and the results are summarized in Table 6.

2.6.7.4. Uncertainty in the Baseline Public Health Assessment

Uncertainties are associated with all estimates of potential carcinogenic risk and noncarcinogenic hazard. For example, the exposure parameters recommended by the U.S. EPA (1990b; 1991) are typically obtained from the 90th or 95th percentile of a distribution; they are not necessarily representative of an average individual or of average exposure conditions. Consequently, use of multiple upper-bound parameters may contribute to overly conservative estimates of potential exposure, risk, and hazard.

In addition, the total cancer risk and/or total HI was calculated by summing risk of HQs for all contaminants at a given location, where each chemical-specific estimate of risk or hazard represents exposures from multiple pathways. Implicit in the summation of risk and hazard, is the assumption that the effects of exposure to more than one chemical are additive. This simplifying assumption does not consider similarities or differences in target organ toxicity, mechanism(s) of action, or the possibility of synergistic or antagonistic effects of different chemicals in the mixture.

Other uncertainties associated with the estimates of risk and hazard are OU-specific and are related to assumptions made in the modeling conducted to provide exposure-point concentrations, which were subsequently used to calculate risk and hazard. Modeling was conducted to provide estimates of exposure-point concentrations that were used to calculate risk and hazard associated with exposure to contaminated ground water migrating from the central and eastern GSA source areas to potential receptor wells CDF-1, SR-1 and at hypothetical wells at the site boundary as discussed in Section 2.6.3.

The following assumptions were made in the ground water modeling, which may result in uncertainties associated with the risk and hazard estimates:

1. The health conservative assumption was made that the 95% UCL for TCE at the central and eastern GSA source areas will reach the site boundary.
2. Human exposure was assumed to result from potentially contaminated ground water if a hypothetical well were to be installed at the site boundary in the near future and was used for residential purposes on a regular basis. However, water in this area is not currently

used for domestic purposes, and Removal Action remediation activities are currently underway to remove ground water contaminants.

In addition, the private land directly adjacent to the GSA source areas is open rangeland, and we are not aware of any plans to build homes or install wells there in the near future.

3. The source terms for plume migration in both the central and eastern GSA were assumed to remain constant despite ongoing and planned remediation activities in the GSA. Any change in the source term would result in a direct proportional change in the exposure-point concentration used to calculate risk and hazard.
4. Both the source concentration and volumetric flow rate, which define the source term, were estimated at the high end of their expected range.
5. A dilution factor was applied to well CDF-1 to estimate exposure-point concentrations based on contaminant concentrations detected in different water-bearing zones from which well CDF-1 pumps water. Changes in the dilution factor would cause a direct proportional change in the estimated TCE exposure-point concentration used to calculate risk and hazard.
6. Other assumptions were made to define model parameters such as porosity, ground water velocity, dispersivity ratio, and TCE decay half-life used in modeling. The sensitivity of the predicted maximum exposure-point concentration to these input parameters is discussed in Appendix P-20 of the Site 300 SWRI.

The cumulative excess cancer risk calculated for Building 875 indoor air was based on VOC concentrations from soil samples collected from the vicinity of the Building 875 dry well pad prior to startup of the SVE system. It is likely, due to ongoing soil remediation activities through SVE, that current VOC soil concentrations are lower than what was used to calculate excess cancer risk in the baseline risk assessment. In addition, Building 875 is located approximately 35 ft from the dry well pad source area. Therefore, the soil concentration and resulting soil vapor concentrations under Building 875 are likely to be lower than those used to calculate the inhalation risk inside Building 875.

2.6.8. Summary of the Baseline Ecological Assessment

The baseline ecological assessment, conducted to evaluate the potential for adverse impact to plants and animals from long-term exposure to contaminants in the GSA OU, determined that VOCs do not pose ecological risk in this area. This determination was based on estimates of potential hazard from exposure to contaminants that were calculated for mammal and aquatic species that could potentially inhabit this area, as well as biological surveys conducted to determine which species actually inhabit or migrate through the GSA.

A detailed discussion of the baseline ecological assessment can be found in Section 1.6.4.1 of the GSA FS (Rueth and Berry, 1995).

2.7. Description of Remedial Action Alternatives

The FS for the GSA OU presented three remedial action alternatives to address 1) potential risk posed by ingestion of VOCs in ground water, and 2) potential VOC inhalation risks inside

Building 875. The three remedial action alternatives are summarized in Table 7. It should be noted that the estimated costs for all alternatives presented in this ROD are lower than the cost estimates presented in the GSA FS and Proposed Plan. This is due to subsequent modifications to the 1) contingency point-of-use treatment component based on negotiations with the well owner, and 2) ground water monitoring component based on changes made to the eastern and central GSA treatment facility monitoring program permit requirements.

2.7.1. Alternative 1—No Action

A no-action alternative is required by CERCLA as a basis from which to develop and evaluate remedial alternatives and is the postulated basis of the baseline risk assessment. Under a no-action response, all current remedial activities in the GSA OU would cease. However, the following activities would be performed:

- Monitoring of VOCs in ground water, reporting, maintenance, database management, and quality assurance/quality control (QA/QC).
- Administrative controls including restricting access to or activities in certain areas of contamination, as necessary.

Modeling indicates that ground water VOC concentrations would be reduced to drinking water standards through natural attenuation and degradation after 75 years under the Alternative 1 scenario. Ground water monitoring would be conducted for the 75-year period plus five years of post-“remediation” monitoring.

The estimated 80-year present-worth cost of Alternative 1 is \$3.47 million. Present-worth cost analysis is a method of evaluating total costs (i.e., the cost of each remedial alternative) for projects that vary in duration by discounting all costs to a common base year (1995) to adjust for the time value of money. The present-worth cost represents the amount of money, which if invested in the initial year (1995) of the remedial action and dispersed over the life of the project, would be sufficient to cover all associated costs.

2.7.2. Alternative 2—Exposure Control

The objective of Alternative 2 is to protect human health by preventing human exposure to TCE and other VOCs through ingestion of ground water from existing water-supply wells by reducing VOC concentrations in water from these wells to drinking water standards (MCLs) through POU treatment. Drinking water standards and MCLs are discussed in Section 2.10.1. Hereafter, drinking water standards will be referred to as MCLs throughout this ROD.

Alternative 2 includes:

- Monitoring and administrative control components of Alternative 1.
- Contingency POU treatment for three offsite water-supply wells: CON-1, CDF-1, and SR-1 (Fig. 10).

As with Alternative 1, reduction of VOC concentrations in ground water through natural attenuation and degradation would take approximately 75 years under the Alternative 2 scenario. Ground water monitoring would be conducted for the 75-year period plus five years of post-“remediation” monitoring.

The present-worth cost of Alternative 2 is \$3.69 million.

2.7.3. Alternative 3—Source Mass Removal and Ground Water Plume Control

The objectives of Alternative 3 are to provide increased protection of human health and the environment by: 1) reducing VOC concentrations in ground water to MCLs, 2) reducing residual VOC (DNAPL) mass/volume, 3) reducing VOC concentrations in soil vapor to levels protective of ground water, and 4) mitigating VOC inhalation risk inside Building 875. These objectives will be accomplished through VOC mass removal from contaminant source areas and plume migration control.

Alternative 3 includes all the elements of Alternatives 1 and 2 and adds ground water and soil vapor extraction to remove TCE and other VOCs from ground water, soil and rock. Alternative 3 is divided into two scenarios: Alternatives 3a and 3b. Both are the same with respect to the objective and method of subsurface soil/rock remediation, but differ in their ultimate objectives for ground water remediation. Both Alternative 3a and 3b include:

- All elements of Alternatives 1 and 2.
- Soil vapor extraction and treatment in the central GSA dry well source area.
- Ground water extraction and treatment in the central and eastern GSA.

Under both Alternatives 3a and 3b, DOE would continue to operate the existing soil vapor extraction system at the central GSA dry well area to reduce VOC concentrations in soil vapor to levels protective of ground water and to mitigate VOC inhalation risk inside Building 875. Modeling indicates that soil vapor extraction would reduce soil vapor VOC concentrations to the remediation goals within 10 years. The ground water remediation components of Alternatives 3a and 3b are discussed further below.

2.7.3.1 Alternative 3a—Source Mass Removal, Restoration of the Regional Aquifer and Ground Water Plume Control

Under Alternative 3a, DOE would expand the existing ground water extraction and treatment system in the central GSA dry well area to prevent migration of VOCs above MCLs into the regional aquifer. In addition, ground water in the eastern GSA debris burial trenches area and the debris burial trench area west of the sewage treatment pond would be extracted and treated to reduce VOC concentrations to MCLs in the alluvial and regional aquifers.

Modeling indicates that TCE concentrations in the shallow aquifer in the central GSA dry well area need to be reduced to 100 µg/L to prevent migration of VOCs above MCLs into the regional aquifer. After the 100 µg/L remediation goal is achieved, ground water extraction would be discontinued and natural attenuation would reduce VOC concentrations in the shallow water bearing zone (Qt-Tnsc₁ hydrogeologic unit) to MCLs.

The existing ground water extraction and treatment system in the eastern GSA debris burial trenches area would continue to operate to reduce VOC concentrations in ground water to MCLs in the shallow and regional aquifers.

Modeling indicates that ground water extraction would reduce ground water VOC concentrations in Building 875 and debris burial trenches areas to MCLs within 30 years and 10 years, respectively. Modeling also indicates that an additional 35 years may be required to reduce VOC concentrations to MCLs in the shallow aquifer in the central GSA through natural attenuation and dispersion. The configuration and operation of both the central and eastern GSA treatment systems would be optimized during remediation to maximize system efficiency. Ground water monitoring would be conducted throughout this 65-year period to achieve MCLs in both the shallow and regional aquifer plus five years of post-remediation monitoring.

The estimated 70-year present-worth cost of Alternative 3a is \$17.17 million.

2.7.3.2 Alternative 3b—Source Mass Removal, Restoration of the Shallow and Regional Aquifer and Ground Water Plume Control

Alternative 3b consists of all components of Alternative 3a but continues active ground water extraction and treatment in the central GSA dry well area until MCLs are reached in all affected ground water. Modeling indicates that ground water extraction in the central GSA dry well area would reduce VOC concentrations to current MCLs in 55 years. Ground water monitoring will be conducted throughout the 55 years of remediation, plus five years of post-remediation monitoring.

The estimated 60-year present-worth cost of Alternative 3b is \$18.90 million. This estimated cost for Alternative 3b is slightly lower than the estimated cost presented in the GSA FS (\$19.75 million) for reasons already discussed in the introduction to Section 2.7.

2.8. Summary of Comparative Analysis of Alternatives

The characteristics of the three alternatives were evaluated against the nine EPA evaluation criteria:

- Overall protection of human health and environment.
- Compliance with ARARs.
- Short-term effectiveness.
- Long-term effectiveness and permanence.
- Reduction of contaminant toxicity, mobility, or volume.
- Implementability.
- Cost effectiveness.
- State acceptance.
- Community acceptance.

As specified by EPA, the two most important criteria are adequate protection of public health and the environment and compliance with all Federal and State ARARs. In the following sections and Table 8, Alternatives 1 through 3 are compared against these nine criteria.

Additional details of the evaluation of these remedial alternatives with respect to the EPA evaluation criteria can be found in Chapter 5 of the GSA FS (Rueth and Berry, 1995).

2.8.1. Overall Protection of Human Health and the Environment

- Alternative 1 does not actively remediate contaminated soil or ground water and thus would not protect human health or the environment because the potential beneficial uses of ground water would not be readily restored and the potential risk associated with the inhalation of VOCs above health-based concentrations in Building 875 are not mitigated.
- Alternative 2 protects human health by preventing ingestion of ground water containing VOCs above MCLs. However, because VOCs are not actively remediated, potential beneficial uses of ground water would not be readily restored. As with Alternative 1, this alternative does not prevent potential inhalation of VOCs above health-based concentrations in Building 875.
- Alternative 3a uses exposure control methods and administrative controls to provide initial protection to human health. This alternative would also protect human health by restoring and protecting the beneficial uses of ground water in the Tnbs₁ regional aquifer through active remediation. Alternative 3a protects human health by preventing potential inhalation of VOCs above health-based concentrations in Building 875 by reducing soil vapor VOC concentrations through soil vapor extraction. Alternative 3a would employ ecological surveys and appropriate response actions, if necessary, to protect the environment.
- Alternative 3b uses exposure control methods and administrative controls to provide initial protection to human health. This alternative also protects human health by restoring and protecting the beneficial uses of ground water in both the shallow and Tnbs₁ regional aquifer through active remediation. Alternative 3b protects human health by preventing potential inhalation of VOCs above health-based concentrations in Building 875 by reducing soil vapor VOC concentrations through soil vapor extraction. Alternative 3b employs ecological surveys and appropriate response actions, if necessary, to protect the environment.

2.8.2. Compliance with ARARs

A complete discussion of potential ARARs related to the three proposed remedial alternatives is presented in the GSA FS, and summarized in Section 2.10 of this report.

- Alternative 1 meets all ARARs if natural attenuation and dispersion reduce VOC concentrations in ground water to MCLs. If natural attenuation and dispersion do not occur, VOC concentration would remain well above MCLs, which would not meet the requirements of the following ARARs: Safe Drinking Water Act, the Region V Basin Plan, or State Resolutions 68-16 and 92-49.
- Like Alternative 1, Alternative 2 would rely solely on natural attenuation to meet remediation goals, and therefore may not comply with the requirements of the Safe Drinking Water Act, the Region V Basin Plan, and State Resolutions 68-16 and 92-49.

- The goal of Alternative 3a is to use active soil vapor and ground water remediation to meet the requirements of the Safe Drinking Water Act, the Region V Basin Plan, and State Resolutions 68-16 and 92-49 in the Tnbs₁ regional aquifer. This alternative relies, in part, on natural attenuation and dispersion, and therefore may not meet these ARARs in the alluvial aquifer in the central GSA.
- Alternative 3b would use active soil vapor and ground water remediation to meet all ARARs in both the alluvial and Tnbs₁ regional aquifer.

2.8.3. Short-Term Effectiveness

- Alternative 1 would not remove VOCs from the subsurface. Therefore, this alternative would not be effective in short-term remediation of the site.
- Alternative 2, while preventing human exposure through ingestion of VOCs in ground water from existing water-supply wells, does not address risk to human health from potential exposure to VOC vapors inside Building 875. Because this alternative does not actively reduce VOC mass, it would not provide short-term remediation of the site.
- Alternative 3a would immediately protect the public from potential exposure pathways. This alternative uses ground water and soil vapor extraction to immediately begin removing VOCs and reducing VOC concentrations in ground water and soil vapor, and would be effective in the short term.
- Like Alternative 3a, Alternative 3b immediately protects the public from potential exposure pathways. This alternative uses ground water and soil vapor extraction to immediately begin removing VOCs and reducing VOC concentrations in ground water and soil vapor.
- All alternatives would be effective in the short term by protecting site workers and the community during the remedial action by preventing potential exposure through the use of administrative controls. No adverse environmental impacts are anticipated.

2.8.4. Long-Term Effectiveness and Permanence

- Alternative 1 would not use active measures to reduce VOCs in ground water. It does not address potential risk from ingestion of VOCs in ground water from existing water supply wells or potential inhalation risk inside Building 875. Therefore, this alternative would not be effective in long-term remediation of the site.
- Alternative 2 would provide protection from exposure risk at existing water-supply wells by providing immediate and long-term response if VOCs greater than MCLs reach these wells. However, since this alternative does not reduce VOC mass or address potential inhalation risk inside Building 875, it would not be an effective long-term remedy.
- Alternative 3a would use ground water and soil vapor extraction to permanently reduce VOC concentrations to MCLs in the Tnbs₁ regional aquifer. However, this alternative relies on natural attenuation to reduce VOC concentrations to MCLs in the alluvial aquifer in the central GSA. Because the reliability of natural attenuation to reach MCLs is uncertain, this alternative may not provide an effective long-term remedy. Alternative

3a would permanently reduce VOC soil vapor concentrations to levels protective of ground water and mitigate inhalation risk inside Building 875.

- Alternative 3b would provide an effective long-term remedy by permanently reducing VOCs to MCLs in both the alluvial and Tnbs₁ regional aquifer through active remediation. Alternative 3b will permanently reduce VOC soil vapor concentrations to levels protective of ground water and mitigate inhalation risk inside Building 875.

2.8.5. Reduction of Contaminant Toxicity, Mobility, or Volume

- Alternatives 1 and 2 do not actively remove VOCs from the subsurface. These alternatives are dependent on natural attenuation processes that may not be effective in reducing toxicity, mobility, or volume of the VOCs.
- Soil vapor and ground water extraction in Alternative 3a would significantly reduce the toxicity, mobility, and volume of contaminants in the subsurface through active remediation measures.
- Alternative 3b will significantly reduce the toxicity, mobility, and volume of contaminants in the subsurface through active ground water and soil vapor remediation.

2.8.6. Implementability

- Alternative 1 could be easily implemented by utilizing the existing ground water monitoring program.
- Alternative 2 could be implemented using the existing ground water monitoring program and readily available services and materials for POU treatment system construction and operation.
- Alternative 3a could be easily implemented utilizing soil vapor and ground water extraction and treatment systems which are currently in place, permitted, and operating in the GSA. Modifications to these systems proposed in Alternative 3a are readily implementable.
- Alternative 3b could be easily implemented utilizing soil vapor and ground water extraction and treatment systems which are currently in place, permitted, and operating in the GSA. Modifications to these systems proposed in Alternative 3b are readily implementable.

2.8.7. Cost Effectiveness

The cost estimates prepared for the remedial alternatives, as well as the assumptions made in preparing these estimates, are described in detail in Appendix F of the GSA FS. The cost estimates may change as the result of modifications during the remedial design and construction process. Any revisions to the cost estimates will be presented in the Remedial Design Document.

- The estimated present-worth cost of Alternative 1 is \$3.47 million for up to 80 years of ground water monitoring. This alternative has the lowest cost because it does not include active remedial actions.
- The estimated present-worth cost of Alternative 2 is \$3.69 million. This includes up to 80 years of ground water monitoring and contingency POU treatment at existing water supply wells, if necessary. Alternative 2 has a higher cost because it includes capital construction projects (construction and installation of POU treatment systems) and ground water monitoring, but no active remediation by long-term extraction and treatment.
- The estimated present-worth cost of Alternative 3a is \$17.17 million. This includes up to 10 years of SVE, ground water extraction for up to 10 years in the eastern GSA and 30 years in the central GSA, and up to 70 years of ground water monitoring. The higher cost of Alternative 3a is due to capital construction projects, extraction and treatment system modifications, installation of additional extraction wells and piezometers, as well as long-term extraction and treatment system operation and maintenance and ground water monitoring. The costs incurred to implement Alternative 3a are associated with the active remediation of soil and ground water in the GSA. Remediation would continue until VOC concentrations in ground water are reduced to MCLs in: 1) the Tnbs₁ regional aquifer in the central GSA, and 2) the alluvial aquifer and the Tnbs₁ regional aquifer in the eastern GSA. Also, VOC concentrations in soil vapor will be reduced to levels protective of ground water and to mitigate inhalation risk inside Building 875.
- The estimated present-worth cost of Alternative 3b is \$18.90 million. This includes up to 10 years of SVE, ground water extraction for up to 10 years in the eastern GSA and 55 years in the central GSA, and up to 60 years of ground water monitoring. This alternative has the highest present-worth cost because it includes all the costs of Alternative 3a but operates the central GSA ground water extraction system for an additional 25 years. As with Alternative 3a, the costs incurred to implement Alternative 3b are associated with the active remediation of soil and ground water in the GSA. However, the cost of Alternative 3b is higher due to the continued remediation of ground water to reduce VOC concentrations to MCLs in both the alluvial and Tnbs₁ regional aquifers. The cost difference between Alternative 3a and 3b represents the additional cost of remediating ground water in the Qt-Tnsc₁ aquifer in the central GSA to reduce VOC concentrations to MCLs.

2.8.8. State Acceptance

The State regulatory agencies, DTSC, and CVRWQCB have provided ARARs for the site, reviewed and evaluated the remedial technologies and alternatives, participated in the selection of the final remedy, and provided oversight and enforcement of State environmental regulations. The DTSC and the CVRWQCB concur with the U.S. EPA and DOE that Alternative 3b provides the best balance of trade-offs with respect to the evaluation criteria.

2.8.9. Community Acceptance

The regulatory agencies have monitored and reviewed public acceptance of the final selected remedy. Public comments concerning each alternative and the selected remedy have been considered and used, as appropriate, in the preparation of this ROD. All public comments on the Proposed Plan, and selected remedy for the GSA are addressed in the Responsiveness Summary section of this document.

2.9. Selected Remedy

DOE, U.S. EPA, CVRWQCB, and DTSC agree that Alternative 3b is the most appropriate remedial alternative, considering the CERCLA evaluation criteria. Under Alternative 3b, DOE will continue subsurface remediation using ground water extraction coupled with SVE to reduce potential risk and contaminant mass. Throughout the remediation process, other more innovative remediation technologies will be considered to enhance VOC mass removal and treatment of extracted soil vapor and/or ground water. *In situ* innovative technologies for VOC remediation will also be considered.

This discussion of the selected remedy includes cleanup goals for the media of concern, details of the remedy components, extraction and treatment system design and operation, performance evaluations, consideration of innovative technologies, reporting, and a summary of preliminary cost estimates.

2.9.1. Cleanup Goals

The objectives of the selected remedial alternative are to: 1) reduce VOC concentrations in ground water to levels protective of human health and the environment, 2) reduce VOC concentrations in soil vapor to meet ground water cleanup goals, and 3) mitigate VOC inhalation risk inside Building 875.

Objectives 1 and 2 will be accomplished by ground water extraction and treatment to reduce VOC concentrations to MCLs, supplemented with soil vapor extraction and treatment to reduce soil vapor concentrations to meet ground water cleanup goals. Objective 3 will be accomplished with the existing SVE system used to accomplish objectives 1 and 2. Soil vapor concentrations protective of ground water are significantly lower than concentrations required to reduce inhalation risk inside Building 875.

2.9.1.1. Ground Water Cleanup Goals

The cleanup goal for ground water is to reduce VOC concentrations to MCLs in all impacted ground water in the GSA. The current MCLs for the VOC contaminants of concern in ground water in the GSA are presented in Table 9. Ground water monitoring will be conducted as discussed in Sections 2.9.2.1 and 2.9.3.1 to determine when MCLs for the contaminants of concern have been achieved in ground water.

2.9.1.2. Soil Vapor Cleanup Goals

Protection of Ground Water

One objective of SVE at the Building 875 dry well pad is to reduce VOC mass and concentrations to meet ground water cleanup goals. The VOCs in the vadose zone will be remediated to the extent technically and economically feasible to minimize further degradation of the ground water by the contaminants in the vadose zone. It is generally preferable from a technical and cost perspective to cleanup contamination in the vadose zone before it reaches the ground water. The vadose zone cleanup will be achieved when it is demonstrated that:

- 1) The remaining vadose zone VOC contaminants no longer cause concentrations in the leachate to exceed the aquifer cleanup levels, based on an interpretation of soil vapor data using an appropriate vadose zone model. Leachate is the mobile portion of water in the vadose zone containing soluble constituents that has been leached from the soil in the vadose zone. Aquifer cleanup levels have been established as MCLs as defined in applicable Federal and State safe drinking water standards; and
- 2) VOCs have been removed to the extent technically and economically feasible in order to meet the aquifer cleanup levels sooner, more cost-effectively, and more reliably.

The SVE system will be operated until the demonstration is made that Items 1 and 2 above have been met, unless the parties consent to the use of an alternate technology for the purpose of meeting the requirements outlined in Items 1 and 2 above. DOE, U.S. EPA, DTSC, and the CVRWQCB agree to evaluate the performance of the SVE system, as well as to determine when vadose zone cleanup has been achieved based on the technical criteria discussed in Section 2.9.3.2.

Risk Reduction within Building 875

The SWRI baseline risk assessment indicated that the cumulative potential excess cancer risk from inhalation of indoor air within Building 875 was 10^{-5} . This calculation was based on VOC concentrations from soil samples collected in the vicinity of the Building 875 dry well pad prior to the July 1994 startup of the SVE system. It is likely, due to nearly two years of ongoing SVE soil remediation, that current VOC soil concentrations are lower than what was used to calculate this excess cancer risk in the baseline risk assessment. Soil vapor concentrations protective of ground water are significantly lower than concentrations that will be required to reduce potential inhalation risk inside Building 875. DOE will conduct soil vapor monitoring, as discussed in Section 2.9.3.2, and use these data to validate reduction of potential inhalation risk inside Building 875.

2.9.2. Treatment System Design

The majority of the remediation components are readily implementable with minor modifications to the existing soil vapor and ground water extraction and treatment systems at the GSA OU.

The major components of the selected remedy (Alternative 3b) include:

- Ground water monitoring throughout the predicted 55 years of remediation plus five years of post-remediation monitoring.
- Administrative controls including access restrictions and procedures for construction in areas where possible exposure to contaminated media may occur.
- Contingency POU treatment for offsite water-supply wells.
- Soil vapor extraction and treatment in the central GSA dry well source area.
- Extraction and treatment of ground water in the central and eastern GSA.

The design, operational, and/or implementation details of these components are discussed in detail in the following sections.

2.9.2.1. Monitoring and Administrative Controls

Monitoring

Currently, the preliminary ground water monitoring program for the selected remedy (Alternative 3b) consists of sampling 7 wells quarterly, 89 wells semiannually, and 12 wells annually for the first 10 years. Between years 11 and 55, after the eastern GSA ground water extraction system and two of the central GSA extraction wells have been turned off, sampling frequency will be reduced to semiannually for 39 wells, and annually for 50 wells. After 55 years, when ground water fate and transport modeling predicts that VOC concentrations in ground water have been reduced to MCLs and the central GSA ground water extraction system can be turned off, ground water sampling will be reduced further to semiannually for 37 wells and annually for 37 wells for the five years of post-remediation monitoring. Samples will be analyzed for VOCs by EPA Method 601, and some wells in the central GSA would also be analyzed for fuel hydrocarbons by EPA Method 602. If remediation does not show that cleanup is proceeding as the modeling predicts, remediation methods will be revisited.

Consistent with the NCP, the ground water data obtained as part of the monitoring program will be reviewed at least every five years. If these data indicate that VOC concentrations, ground water flow direction, and/or velocity have changed and significantly affect the cleanup, the monitoring program would be re-evaluated.

Soil vapor concentrations will be monitored periodically from the seven extraction wells during the predicted 10 years of SVE to evaluate remediation progress and provide data for system optimization. VOC concentrations in soil vapor samples can be used to determine if there is preferential VOC removal from certain SVE wells. This information will be used to vary the extraction configuration to optimize VOC mass removal from soil vapor; i.e., extract from wells with higher VOC soil vapor concentrations while using wells with lower VOC concentrations as air inlet wells. The configuration and operation of the SVE system will be optimized during remediation to maximize system efficiency.

In addition, existing soil vapor monitoring points in the vicinity of Building 875 will be monitored for TCE and PCE. The TCE and PCE concentrations will be used to periodically evaluate the effectiveness of SVE in mitigating inhalation risk inside Building 875.

Although the inhalation risk inside Building 875 was calculated by adding the individual lifetime cancer risk for a total of six VOCs, the sum of the individual cancer risks for TCE and PCE (1.11×10^{-5}) constitutes the largest portion of the total additive inhalation cancer risk inside Building 875 (1.17×10^{-5}). For this reason, TCE and PCE will be used as the indicator VOCs for periodically assessing additive inhalation cancer risk inside Building 875. Once the additive inhalation risk reaches acceptable levels for TCE and PCE, soil vapor samples will be collected and analyzed for all six VOCs originally used to calculate inhalation risk inside Building 875 in the SWRI. These data will then be used as direct input parameters to the models that were used to calculate inhalation risk in the SWRI to calculate a total additive inhalation cancer risk inside Building 875.

Soil vapor monitoring will be discussed in detail in the remedial design document.

Specific details of the ground water and soil vapor monitoring network will be presented in the Remedial Design document.

Additionally, surface water from springs 1, 2, and GEOCRK will be sampled and analyzed for VOCs, drinking water metals, general minerals, high explosives, tritium, and gross alpha and beta as part of ongoing site-wide program of ecological studies. The current program of conducting ecological resource surveys for sensitive species prior to the initiation of any ground-disturbing activities will also continue. The need for detailed ecological resource surveys will be evaluated every five years as part of the contract renewal negotiations between the University of California and DOE.

Administrative Controls

The following administrative controls are a component of the selected remedy and are either currently in effect or easily implementable. Because DOE intends to retain stewardship of Site 300 for the foreseeable future, existing security patrols, site access restrictions, and fencing along the entire perimeter of Site 300 will be maintained. These restrictions will prevent public access, and thus potential exposure, to the source areas and areas of highest ground water VOC concentrations. Additionally, DOE will continue to consider site conditions (especially in the vicinity of vadose zone contamination) prior to implementing construction of any facility to prevent potential worker exposure to subsurface contaminants.

2.9.2.2. Contingency Point-of-Use Treatment

POU treatment systems will be installed at offsite water-supply wells CON-1, CDF-1 and SR-1 (Fig. 10) if VOCs in these wells are at or above MCLs. As part of the monitoring plan, water-supply wells CON-1 and CDF-1 will be monitored for VOCs monthly. Guard wells W-25D-01, W-25D-02, and W-24P-03, located the farthest downgradient from the source and upgradient from water-supply well SR-1, will also be monitored for VOCs. Well W-24P-03 will be monitored quarterly, and wells W-25D-01 and -02 monitored semiannual. If VOCs are detected in well W-24P-03, the monitoring frequency of this well will be increased to monthly, and wells W-25D-01 and -02 monitored quarterly. Should VOCs be detected in well W-24P-03,

provisions will be made to routinely sample well SR-1. In the event that VOCs at or above MCLs are detected and confirmed in wells CDF-1, CON-1, or SR-1, implementation of POU treatment at that well will be discussed with the regulatory agencies and well owner(s).

Wells CDF-1 and CON-1 are located approximately 100 and 200 ft, respectively, from the Site 300 GSA boundary. Due to the close proximity of these wells to the VOC plume, DOE currently has a POU contingency plan in place for these wells in a Memorandum of Understanding that has been reviewed and approved by the well owner.

Well SR-1 is located approximately 1.5 miles downgradient from guard well W-24P-03. No VOCs have ever been detected in ground water collected from W-24P-03, the furthest downgradient well. In addition, the VOC plume has been receding upgradient back toward Site 300 as result of remediation efforts and is currently over 2 miles from well SR-1. However, if VOCs were detected in guard well W-24P-03, the property owner would be contacted to set up a contingency plan similar to that established for wells CON-1 and CDF-1.

The conceptual POU treatment system design consists of a gravity-flow aqueous-phase GAC treatment system utilizing two GAC canisters connected in series and mounted on a double-containment skid. Sampling ports will be provided between the canisters, as well as at the inlet and exit pipes. Other equivalent treatment technologies may be considered, if appropriate.

In the event that POU treatment becomes necessary, DOE will develop and submit a plan for regulatory approval to permanently remedy the affected water supply.

2.9.2.3. Soil Vapor Extraction and Treatment

SVE will be used as the primary remedial technology to: 1) reduce vadose zone contamination, including potential DNAPLs in unsaturated bedrock, to concentrations protective of ground water, and 2) reduce potential inhalation risk inside Building 875. Most vadose zone contamination is found in the immediate vicinity of the Building 875 dry well pad, so SVE efforts will be focused in that area.

Residual DNAPLs may be in the vadose zone and dewatered bedrock in the vicinity of the Building 875 dry well pad. The dewatered zone consists of bedrock that was formerly saturated prior to the initiation of ground water extraction activities in the central GSA, but is now unsaturated or dry due to pumping. SVE and treatment would also address residual DNAPLs. SVE has been identified as a technology that can effectively remediate volatile DNAPLs in the unsaturated zone and prevent uncontrolled migration of VOCs in soil gas (U.S. EPA, 1992d; 1993b). In addition, when SVE is coupled with lowering of the water table through ground water extraction, residual DNAPLs can be removed from the area below the original water table elevation (U.S. EPA, 1992d).

In July 1994, soil vapor extraction and treatment activities were initiated in the central GSA Building 875 dry well pad area. The current SVE system uses seven extraction wells and treats the vapor with two 140-lb vapor-phase GAC canisters connected in series prior to discharge to the atmosphere. The locations of the SVE wells are shown in Figure 11. VOC concentrations in the SVE-combined influent stream have decreased from a high of 450 ppm_{v/v} in July 1994 to current concentrations of 5 ppm_{v/v} or below in the second quarter 1996. Similarly, VOC concentrations in soil vapor samples from the individual SVE wells have decreased from a

maximum concentration of 600 ppm_{v/v} in well W-7I at system startup to a maximum of 33 ppm_{v/v} in well W-875-07 in the second quarter 1996. As of second quarter 1996, 27,238 grams of VOCs have been removed in the central GSA through SVE.

Soil vapor is currently extracted at rate of approximately 20 standard cubic ft per minute. Based on field observations, we estimate that the current system adequately captures the soil vapor plume in the Building 875 dry well pad source area and that no additional SVE wells are necessary. The necessity of performing SVE at other locations in the GSA OU will be evaluated as remediation progresses. Other equivalent soil vapor treatment technologies may be considered, if appropriate.

The seven SVE wells are also used for ground water extraction and are successfully maintaining a dewatered zone in the immediate vicinity of the Building 875 dry well pad. Dewatering has exposed more soil/rock to the applied vacuum of SVE, thereby significantly enhancing VOC mass removal. This dewatered zone will continue to be maintained while SVE is operating.

The central GSA treatment is a dual soil vapor and ground water extraction and treatment system, and both systems will initially be operated simultaneously. Upon reaching conditions presented in Section 2.9.3.2, the soil vapor system will be shut down and only the ground water extraction and treatment system will operate. Should site conditions change or ground water monitoring indicate that soil vapor concentrations have rebounded and will cause ground water to exceed ground water cleanup goals, the soil vapor system will be restarted and operated as appropriate until such conditions cease. DOE agrees to operate the dual soil vapor and ground water extraction and treatment system to reduce ground water VOC concentrations to meet ground water cleanup goals in the most efficient manner.

During preparation of the remedial design report and throughout the life of the project, DOE may conduct more extensive testing to determine the effective vacuum influence and to optimize performance. Optimization may include expanding the SVE system with additional existing wells to increase the area of influence, and/or implementing cyclic operation (e.g., alternating periods when the system is on and off) to maximize the rate of VOC mass removal.

2.9.2.4. Ground Water Extraction and Treatment

Eastern GSA

As shown in Figure 8, ground water concentrations exceed MCLs in the eastern GSA in the vicinity of the former debris burial trench area, east of the sewage treatment pond. Ground water extraction and treatment in this area is designed to reduce ground water VOC concentrations to MCLs.

The eastern GSA ground water extraction system has been operating since July 1991, and currently consists of three extraction wells pumping a total of up to 46 gal per minute (gpm). As of second quarter 1996, over 76 million gal of ground water have been extracted and treated in the eastern GSA ground water treatment system with 4,417 grams of VOCs removed from ground water.

Data collected through fourth quarter 1995 indicate that TCE concentrations have been generally decreasing in all eastern GSA alluvial wells since 1992. There was an average TCE concentration decrease of 75% in eastern GSA alluvial wells between the historical maximum concentration and the concentration in third quarter 1994. The maximum observed TCE concentration in eastern GSA alluvial wells in fourth quarter 1995 was 18 µg/L in well W-26R-01, a significant decrease from the historical maximum concentration of 74 µg/L TCE in well W-26R-03 in January 1992.

The 1 µg/L isoconcentration contour for the ground water VOC plume in the eastern GSA previously extended 4,750 ft downgradient from the debris trench area and the 5 µg/L isoconcentration contour extended 4,625 ft downgradient based on fourth quarter 1991 (SWRI) data (Fig. 12). Fourth quarter 1995 data indicate that the 1 µg/L isoconcentration contour for the ground water VOC plume now extends only 1,950 ft downgradient from the debris burial trench area, while the 5 µg/L isoconcentration contour extends only 600 ft downgradient (Fig. 8). Remediation efforts in the eastern GSA are thought to be at least partially attributable to this decrease in plume length.

VOC concentrations in the regional aquifer in the eastern GSA have also been significantly decreasing as a result of existing alluvial ground water remediation. TCE concentrations have decreased in ground water in the Tnbs₁ regional aquifer from a maximum of 71 µg/L in third quarter 1992, to a maximum of 19.2 µg/L in fourth quarter 1995 as shown in Figures 13 and 9, respectively. In this area, the alluvium and underlying regional aquifer are hydraulically connected, and contamination in the regional aquifer is a result of downward vertical migration of contaminants from the alluvial aquifer. An extraction well in the regional aquifer in the debris burial trench area was not considered due to concerns that pumping the regional aquifer would accelerate/facilitate downward vertical contaminant migration from the overlying source in the alluvium into the Tnbs₁. If remediation of the alluvial aquifer does not appear effective in removing VOCs from ground water in the regional aquifer in the future, direct remediation of the regional aquifer in the eastern GSA will be considered.

Based on modeling and field data associated with the existing extraction system, the extraction well configuration shown in Figure 11 sufficiently captures the plume in the eastern GSA to meet remediation goals. The portion of the plume downgradient of the eastern GSA extraction wells that is not being actively captured has been retreating since ground water extraction was initiated. We anticipate this trend will continue. Therefore, no additional wells are necessary at this time. The effectiveness of this system is discussed in Section 1.4.8.2 of the GSA FS.

Ground water modeling predicts that the eastern GSA ground water extraction and treatment system will remediate ground water to MCLs in five years. However, we have conservatively assumed that this system will need to operate for ten years.

In the GSA FS, a low-profile shallow-tray air stripper was the chosen treatment system for ground water in the eastern GSA. Aqueous-phase GAC was not a selected technology in the FS due to concerns regarding possible biofouling and clogging that might require premature GAC replacement, and thereby reduce system efficiency. The FS also stated that aqueous-phase GAC treatment was being further evaluated as a component of the final system design. Since issuing the GSA FS in October 1995, aqueous-phase GAC was evaluated for ground water treatment in the eastern GSA. This evaluation consisted of:

1. Reviewing ground water chemistry data from eastern GSA extraction wells to evaluate the potential for carbonate clogging or bacterial biofouling of the GAC system.
2. Performing a system test by connecting two aqueous-phase GAC units to the eastern GSA treatment system to monitor the effectiveness of GAC in reducing VOCs, and to identify potential problems such as biofouling and clogging.

Two aqueous-phase GAC units were connected in series prior to the air sparging tank. Water from the eastern GSA extraction wells passed through sediment filters and then went directly into the GAC units. The GAC units were sampled and monitored to ensure VOCs were effectively removed to the NPDES permit required levels, and to evaluate the potential effects of biofouling and carbonate clogging on GAC system efficiency. Following treatment in the GAC units, the water passed through the air sparging tank. The GAC units were evaluated in this manner for eight months, from December 1995 to August 1996. The results of this evaluation indicated that: 1) the aqueous-phase GAC units effectively removed VOCs from ground water to NPDES permit levels ($<0.5 \mu\text{g/L}$), and 2) there is no evidence of system efficiency reduction or premature replacement of GAC due to biofouling and clogging of the GAC units.

As discussed in Section 3.3.5.1.1 of the GSA FS, aqueous-phase GAC adsorption is a well established and effective technology for treating chlorinated solvents in ground water. Activated carbon removes contaminants from water by adsorbing them onto its surface. A GAC adsorption system consists of a packed column with an internal plumbing system to distribute the water evenly through the carbon bed. Organic compounds adsorb onto the surface of the GAC as the water flows through the fixed bed.

Aqueous-phase GAC treatment is generally considered to be most effective for low-flow and low-concentration applications. Influent TCE concentrations to the eastern GSA treatment system have steadily declined from a high of $63 \mu\text{g/L}$ in September of 1991 to an average of $8.2 \mu\text{g/L}$ for the last four quarters (3rd quarter 1995 to 2nd quarter 1996) and continue to decline. The GAC technology was demonstrated to be effective in treating the eastern GSA ground water at these low concentrations.

Aqueous-phase GAC adsorption is a one-step treatment process as opposed to two-step treatment necessary with air stripping where VOCs are removed from water and are then driven into the vapor phase. Following air stripping, the VOC-laden vapors are treated in vapor-phase GAC units. The aqueous-phase GAC technology, which is inherently less complex in both design and operation than air stripping technology, will incur lower operation and maintenance costs over the long term.

The aqueous-phase GAC technology was evaluated in the eastern GSA and was determined to be:

1. Effective in removing VOCs from ground water to NPDES permit levels ($<0.5 \mu\text{g/L}$),
2. Capable of treating water to meet all other NPDES permit discharge limits; i.e., pH and total dissolved solids, and
3. More cost effective for long-term operation and maintenance.

As a result, aqueous-phase GAC has replaced air stripping as the preferred technology for the treatment of ground water in the eastern GSA.

Extracted ground water will continue to be treated by two to three aqueous-phase GAC units connected in series (Fig. 14). Other equivalent ground water treatment technologies may be considered in the future, if appropriate. The system has a treatment flow rate capacity of 50 gpm. Ground water is treated to reduce VOC concentrations to the National Pollutant Discharge Elimination System (NPDES) permit requirements of 0.5 µg/L total VOCs. Treated water will continue to be discharged by gravity flow to Corral Hollow Creek about 750 ft to the south. Discharged treated water will continue to be monitored to ensure compliance with NPDES permit requirements issued by the CVRWQCB.

A portion of the treated water from the eastern GSA treatment facility may occasionally be discharged to sewage treatment pond to the west as makeup water. During the hot, dry summer months, approximately 1,000 to 1,500 gal of makeup water is added to the sewage treatment pond to compensate for evaporation, which is necessary to keep the sewage treatment pond operating efficiently. It is currently being proposed that treated water from either the eastern or central GSA treatment facilities be used as this makeup water. In the event that treated water from the eastern GSA treatment facility is diverted to the sewage treatment pond as makeup water, this will have little overall impact on ground water or Corral Hollow Creek as this treatment facility typically discharges over 40,000 gal a month. Due to the low volume of makeup water required by the sewage treatment pond, and the limited time frame when makeup water is required (summer months only), the majority of the treated water from the eastern GSA treatment facility would continue to be discharged to Corral Hollow Creek, providing recharge to the underlying aquifer.

Central GSA

As shown in Figure 6, most VOCs in the GSA OU subsurface are in the central GSA, primarily in the vicinity of the Building 875 dry well pad. While VOC concentrations in ground water are above MCLs in the Tnbs₁ regional aquifer west of the sewage treatment pond (Fig. 7), the highest ground water VOC concentrations are in the upgradient overlying alluvial aquifer (Fig. 6) at the Building 875 dry well pad. Ground water extraction and treatment in this area is designed to reduce ground water VOC concentrations to MCLs in both the alluvial and Tnbs₁ regional aquifer.

Since April 1993, a ground water treatment system has been in operation in the central GSA at the former Building 875 dry well pad area as part of a CERCLA Removal Action. Currently, the central GSA ground water extraction system pumps a total of approximately 0.3 gpm from seven extraction wells located in the vicinity of the Building 875 dry well pad (Fig. 11). This very low flow rate is a result of the successful dewatering of the area. As of second quarter 1996, over 568,000 gal of ground water have been extracted and treated in the central GSA ground water treatment system and 3,932 grams of VOCs removed from ground water. A comparison of VOC ground water data collected from Qt-Tnsc₁ wells during the third quarter 1994 to the historical maximum observed concentrations indicates an overall decrease in VOC concentrations. Specifically, the maximum observed TCE concentration for all Qt-Tnsc₁ wells in samples collected in the third quarter of 1994 was 10,000 µg/L, representing a decrease from the historical maximum observed concentration of 240,000 µg/L in a bailed ground water sample collected from well W-875-07 in March 1992 (Fig. 15). Third quarter 1994 analytical data suggest that ground water samples collected from the Building 875 dry well pad wells do not

contain TCE at concentration indicative of the presence of DNAPLs in the saturated zone. However, the residual DNAPLs may be present in soil in the dewatered zone and/or vadose zone. The drop in TCE concentrations is thought to be attributable to ground water and soil vapor extraction and treatment efforts ongoing in the central GSA. We have been unable to collect ground water samples from the dry well pad wells since third quarter 1994 because these wells have been effectively dried out preventing ground water sample collection.

Historically, TCE has been detected in ground water samples from monitor wells located west of the sewage treatment pond, which are completed in the Tnbs₁ regional aquifer (Fig. 16). Data indicates that VOC contaminants are in the regional aquifer in the central GSA only where the regional aquifer directly underlies contaminated portions of the alluvial aquifer, such as the area immediately west of the sewage treatment pond. Where present, the Tnsc₁ confining layer acts as a competent confining layer in the vicinity of Building 875 and the areas to the west, preventing TCE migration from the shallow Qt-Tnsc₁ aquifer into the underlying Tnbs₁ regional aquifer.

Data indicate that TCE concentrations have generally been decreasing in all Tnbs₁ monitor wells in the central GSA since 1990. The measured decrease in TCE concentrations may be attributable to the sealing and abandonment of wells 7 and 19 (Fig. 16) in 1988 and 1989. Prior to sealing and abandonment, these wells pumped up to 200 gpm and may have reversed the natural hydraulic gradient, thus causing TCE to migrate into the Tnbs₁ from the overlying alluvium. When pumping ceased from wells 7 and 19, the pre-pumping hydraulic gradient appears to have been re-established in the Tnbs₁ and, as a result, the TCE concentration in the bedrock aquifer have decreased.

In addition to the seven existing ground water extraction wells, six existing monitor wells (W-7F, W-7O, W-872-02, W-7P, W-873-06, and W-873-07) will be converted to ground water extraction wells. Additionally, one new ground water extraction well, W-7Q, will be installed. The purposes of these new ground water extraction wells are to maximize contaminant mass removal in source areas and prevent plume migration in both the alluvial and Tnbs₁ regional aquifer. Extraction from these new ground water extraction wells will increase the total central GSA flow rate from the current 0.3 gpm to approximately 15 gpm.

Ground water monitor well W-7P will be converted to an extraction well to reduce VOC concentrations in the Tnbs₁ regional aquifer west of the sewage treatment pond. However, extraction from this well may not be initiated until alluvial aquifers extraction stabilizes capture zones and further reduces contamination in the alluvial aquifer.

In conjunction with source area ground water extraction described above, ground water will be extracted from three new extraction wells (W-7R, W-7S, and W-7T) to be installed in the alluvial aquifer about 150 ft west of the sewage treatment pond (Fig. 11). These three extraction wells will capture VOCs not captured by the source area extraction wells, and prevent VOCs from migrating into the Tnbs₁ regional aquifer. Ground water extraction from these three wells will likely continue until ground water extraction in the source areas is discontinued.

Modeling predicts that ground water extraction in the central GSA will likely be required for 55 years to reduce VOC concentrations to current MCLs. Extraction from wells W-873-06 and W-873-07 will be discontinued after 10 years if VOC concentrations in the alluvial aquifer in these source areas has reached MCLs, as modeling predicts.

Ground water extracted in the central GSA will be treated using the existing treatment system with upgrades including replacement of the existing air sparging tanks with a low-profile tray air stripper, aqueous-phase granular activated carbon (GAC), or other equivalent technologies to increase VOC removal efficiency and reduce electrical costs (Fig. 17).

Ground water treatment will continue to reduce VOC concentrations to meet the Substantive Requirement of 0.5 µg/L total VOCs. Treated water will continue to be discharged to a remote canyon in the eastern GSA where the water rapidly infiltrates into the sandstone bedrock. Discharged treated water will be monitored to ensure compliance with Substantive Requirements issued by the CVRWQCB. A portion of the treated water from the central GSA treatment facility may occasionally be discharged to the sewage treatment pond to the east as makeup water during the summer months. In the event that treated water from the central GSA treatment facility is diverted to the sewage treatment pond as makeup water, the overall impact on ground water would be minimal as this treatment facility typically discharges 15,000 to 25,000 gal a month to the canyon in the eastern GSA. Due to the low volume of makeup water required by the sewage treatment pond, and the limited time frame when makeup water is required (summer months only), the majority of the treated water from the central GSA treatment facility would continue to be discharged to the eastern GSA canyon, providing recharge to the underlying aquifer.

Once ground water extraction from Tnbs₁ well W-7P is initiated, treated ground water will also be reinjected into well W-7C, screened downdip of W-7P (Fig. 11). Reinjection will enhance natural contaminant flushing toward extraction well W-7P and expedite remediation of the Tnbs₁ regional aquifer. Hydraulic testing will be performed prior to reinjection to ensure that reinjection will not adversely affect remediation effectiveness or accelerate plume migration. In addition to hydraulic testing and prior to reinjection, treated ground water will be analyzed to verify removal of VOCs to discharge requirements (<0.5 µg/L total VOCs). Analyses will also ensure that concentrations of inorganic compounds do not exceed levels found in water extracted from the Tnbs₁ regional aquifer.

If air stripping is selected as the treatment technology, the vapor stream from the air stripper will be treated by two vapor-phase GAC canisters connected in series and discharged to the atmosphere. The treated vapor stream will be monitored to ensure compliance with the San Joaquin Valley Unified Air Pollution Control District permit requirements. If aqueous-phase GAC is selected as the remedial technology, no vapor stream will exist, therefore air discharge permits will not be necessary.

The exact number and location of ground water extraction wells will be presented in subsequent design documents. Similarly, the choice of treatment technologies will be evaluated on an ongoing basis to implement the most cost-effective technology that meets all performance criteria.

2.9.3. Performance Evaluations

Ground water and soil vapor monitoring will be conducted throughout the life of the GSA OU remediation project to evaluate the performance and effectiveness of the treatment systems in meeting remediation goals.

2.9.3.1. Ground Water Remediation

Ground water monitoring, as described in Section 2.9.2.1 will be conducted to evaluate the effectiveness of ground water remediation in reducing VOC concentrations to MCLs in the shallow aquifer and Tnbs₁ regional aquifer. Details of the ground water monitoring network will be presented in the Remedial Design document.

In addition, several new piezometers will be installed for measuring water levels near the extraction wells to help evaluate ground water capture and remediation effectiveness. Locations of these piezometers will be determined after ground water extraction begins in order to optimize piezometer placement, and will be discussed in the Remedial Design report.

When VOC concentrations in ground water have been reduced to cleanup goals (MCLs), the ground water extraction and treatment system(s) will be shut off and placed on standby. Modeling indicates that VOC concentrations in ground water in the eastern GSA should be reduced to MCLs within 10 years following the initiation of remediation and within 55 years in the central GSA. Ground water in the GSA will continue to be monitored for a period of five years following shutdown of the system(s). Should VOC concentrations in ground water “rebound” or increase above cleanup goals, reinitiation of remediation efforts will be discussed with the regulatory agencies. If remediation does not show that cleanup is proceeding as modeling predicts, remediation methods will be revisited.

As presented in the National Research Council report (NRC, 1994), the ability of restoring ground water to MCLs using active pumping is unlikely at most sites. If, at some later date, DOE, U.S. EPA, CVRWQCB, and DTSC determine that it is technically and economically infeasible to reduce VOCs in ground water to the cleanup levels established in this ROD, after all reasonable efforts have been made, these parties may re-evaluate the need to achieve these goals.

Throughout the remediation process, innovative remediation technologies will be considered to enhance VOC mass removal and treatment of ground water, as discussed in Section 2.9.4.

2.9.3.2. Soil Vapor Remediation

The primary objectives of soil vapor remediation at the central GSA are to: 1) reduce vadose zone contamination to concentrations to meet ground water cleanup goals, and 2) reduce potential inhalation risk inside Building 875. Because the second objective will likely be achieved long before achieving the first objective, the performance evaluation of the central GSA SVE system will focus on ground water protection, in accordance with ARARs, State Water Resources Control Board Resolution 92-49, and the Region V Basin Plan.

To monitor the progress of subsurface soil remediation, soil vapor concentrations will be monitored at dedicated soil vapor sampling points and at SVE wells through the life of the SVE remediation. In addition, DOE/LLNL will evaluate SVE remediation effectiveness by tracking the cumulative mass of VOCs removed from the Building 875 dry well pad area. The mass of VOCs removed from soil vapor will be plotted as a function of time to determine when the cumulative mass removed approaches asymptotic levels.

As part of the selected remedy, VOC concentrations in soil vapor will be monitored utilizing soil vapor sampling points to ensure that the inhalation risk inside Building 875 is adequately managed. Should existing dedicated soil vapor monitoring points in the vicinity of Building 875

prove insufficient to demonstrate the effectiveness of soil vapor extraction in mitigating the potential inhalation risk in Building 875, additional soil vapor monitoring points will be considered.

The demonstration that the vadose zone cleanup has been achieved to the point where the remaining vadose zone VOC contaminants no longer cause concentrations in the leachate to exceed the aquifer cleanup levels will be made through contaminant fate and transport modeling, trend analysis, mass balance, and/or other means. This demonstration will include examination of the current effects of remaining vadose zone contamination on the ground water, using an appropriate vadose zone model, if necessary. In the case that it is demonstrated that the soil vapor concentration for TCE has reached 360 parts per billion (ppb) on a volume-to-volume basis (and similarly derived concentrations for other VOCs) in the vadose zone, the parties agree that the demonstration has been made that the remaining vadose zone VOC contaminants will no longer cause concentrations in the leachate to exceed the aquifer cleanup level. If it is demonstrated that there is no water moving through the vadose zone and no potential for leachate to be produced at the current time or in the future, the parties agree that the demonstration that the remaining vadose zone VOC contaminants will no longer cause concentrations in the leachate to exceed aquifer clean-up levels has been made.

The SVE system will be operated until it is demonstrated that VOC removal from the vadose zone is no longer technically and economically feasible in order to meet the aquifer cleanup levels sooner, more cost effectively, and more reliably. This feasibility analysis will include consideration of the follow factors (these factors are not dispositive and other factors may be considered upon agreement of the parties):

- 1) Whether the predicted concentration of leachate from the vadose (using an appropriate vadose zone model that interprets soil gas data) will exceed the ground water cleanup standard;
- 2) Whether the predicted concentration of the leachate from the vadose zone (using an appropriate vadose zone model that interprets soil gas data) will cause the ground water to exceed the aquifer cleanup levels;
- 3) Whether the mass removal rate is approaching asymptotic levels after temporary shutdown periods and appropriate optimization of the SVE system;
- 4) The additional cost of continuing to operate the SVE system at concentrations approaching asymptotic mass levels;
- 5) The predicted effectiveness and cost of further enhancements to the SVE system (e.g., additional vapor extraction wells, air injection) beyond system optimization of the existing system;
- 6) Whether the cost of ground water remediation will be significantly more if the residual vadose zone contamination is not addressed;
- 7) Whether residual mass in the vadose zone will significantly prolong the time to attain the ground water cleanup standard;
- 8) Historic data that present the SVE system operating costs per unit VOC mass removed from the vadose zone and the concurrent soil vapor VOC concentrations, both as a function of time; and

- 9) Historic data that present the ground water extraction and treatment system operating costs per unit VOC mass removed from the ground water and the concurrent ground water VOC concentrations, both as a function of time.

Other factors may be considered upon agreement between DOE, U.S. EPA, CVRWQCB, and DTSC.

The SVE system may be cycled on and off in order to optimize SVE operation and/or to evaluate the factors listed above. DOE, U.S. EPA, CVRWQCB, and DTSC will jointly make the decision that VOC cleanup of the vadose zone has been achieved and the SVE system may be shut off permanently.

If at some later date, DOE, U.S. EPA, CVRWQCB, and DTSC determine that it is technically or economically infeasible to reduce VOCs in the vadose zone to levels which no longer cause concentrations in the leachate to exceed aquifer cleanup levels, after all reasonable efforts have been made, the parties will re-evaluate the need to achieve this goal, provided that VOCs have been removed from the vadose zone to the extent technically and economically feasible and to the satisfaction of the DOE, U.S. EPA, CVRWQCB, and DTSC. This situation will require a more rigorous feasibility analysis because the incremental benefit of removing VOCs from the vadose zone is generally much higher as long as there are VOC contaminants in the vadose zone that cause concentrations in the leachate to exceed aquifer cleanup levels. Aquifer cleanup goals must be met even though the goal to reduce VOCs in vadose zone to levels that no longer cause concentrations in the leachate to exceed aquifer cleanup levels is not achieved.

Throughout the remediation process, innovative remediation technologies will be considered to enhance VOC mass removal and treatment of soil vapor, as discussed in Section 2.9.4.

Once the ground water has reached cleanup levels, DOE, U.S. EPA, CVRWQCB, and DTSC agree that:

- 1) It is not technically and economically feasible to operate the SVE beyond the point where the remaining vadose zone VOC contaminants no longer cause the concentrations in the leachate to exceed the aquifer cleanup level; and
- 2) There is relatively little benefit in continuing SVE because aquifer cleanup levels have been achieved and contaminants in the vadose zone will not cause contaminant concentrations in ground water to increase.

2.9.4. Innovative Technologies

Innovative technologies that shorten cleanup time, improve cleanup efficiency, and reduce cost will continue to be considered for application at the GSA throughout the remediation process. These technologies may be employed at the GSA if site conditions change or technology development and testing indicate a potential for cost-effective and expedited remediation. Innovative technologies will be employed with regulatory agency concurrence.

2.9.5. Reporting

Performance summaries for the ground water and soil vapor extraction and treatment systems will be submitted to the U.S. EPA, DTSC, and the CVRWQCB on a quarterly basis. A schedule for submitting ground water and vadose zone monitoring data and contaminant plume concentration contour maps will be included in the remedial design document.

2.9.6. Summary of Preliminary Cost Estimates

The 1995 present-worth cost of the selected remedy is estimated to be approximately \$18.90 million as detailed in Table 10. Many of the costs for technology development, equipment purchases, and facility construction associated with the implementation of the selected remedy presented in Table 10 have already been incurred. This cost estimate assumes up to 10 years of SVE and monitoring, up to 10 years of ground water extraction in the eastern GSA, up to 55 years of ground water extraction in the central GSA, and up to 60 years of ground water monitoring. These time and cost estimates do not include the development, testing, or implementation of innovative technologies. Cost estimates and equipment may change as the result of modifications during the remedial design and construction processes. Cleanup goals and cleanup time estimates can be re-evaluated with the regulatory agencies every five years, based on the effectiveness of the remediation system, changes in site conditions, and changes in regulatory requirements.

2.10. ARARs

CERCLA Section 121 (d)(2)(A) requires that remedial actions meet any Federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate. CERCLA Section 121 (d)(2)(A)(ii) requires that State ARARs be met if they are more stringent than Federal requirements.

There are three general kinds of ARARs:

1. Chemical-specific requirements that define acceptable exposure concentrations or water quality standards,
2. Location-specific requirements that may restrict remediation activities at sensitive or hazard-prone locations such as wildlife habitat and floodplains, and
3. Action-specific requirements that may control activities and/or technologies.

A list of potential ARARs related to the three proposed remedial alternatives was presented in the GSA FS. ARARs directly related to the selected remedy is contained in Table 11 of this ROD. These ARARs: 1) cite the most directly pertinent requirements related to specific actions to be taken as part of the selected remedy, and 2) provide a mechanism for enforcement of standards directly related to the selected remedy (i.e., NPDES waste water discharge and air discharge permits). When State ARARs are more stringent than Federal requirements, only the State ARAR is listed in the table.

2.10.1. Chemical-Specific ARARs

SWRCB Resolution 92-49 entitled "Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304" is a chemical-specific ARAR for aquifer (ground water) remediation goals. Resolution 92-49 provides general policies on investigation, monitoring, and reporting. All ground water cleanup activities associated with implementation of the selected remedy for the GSA will be conducted under the supervision of the CVRWQCB and in accordance with Resolution 92-49. In addition, Resolution 92-49 authorizes the CVRWQCB to determine cleanup goals which must consider cost effectiveness and technical feasibility.

DOE, the U.S. EPA, State DTSC, and CVRWQCB have agreed to a cleanup goal of drinking water standards (MCLs) for VOCs in ground water in the GSA OU, except as specified below. This cleanup goal is based on the chemical-specific ARARs (State and Federal MCLs) established in the Federal Safe Drinking Water Act and California Safe Drinking Water Act. The Federal and State MCLs for the chemicals of concern in ground water in the GSA OU are given in Table 9. The most stringent concentration limit, in most cases the State MCL, is the governing ARAR for each chemical of concern and will be the cleanup goal for ground water remediation in the GSA.

The CVRWQCB's decision to concur with MCLs as ground water cleanup goals was based on technical and economic information in the GSA FS. The CVRWQCB stated "LLNL/DOE presented costs and time needed to cleanup to MCLs and non-detect for TCE. Based on numerical fate and transport modeling, LLNL/DOE showed that concentrations of TCE would be below the limit of detection (0.5 ppb [$\mu\text{g/L}$]) in all but a 12-acre area in the vicinity of the GSA after 55 years of pumping. The 12-acre area would be below the MCLs, except for an approximately 100 ft-square area at 5 to 10 ppb ($\mu\text{g/L}$). Simulation TCE fate and transport for an additional 35 years (without pumping) showed TCE contamination at or below 1 ppb ($\mu\text{g/L}$), except for about a 100 ft-square area which would be at or below the MCL. LLNL/DOE also simulate 90 years of pumping, which showed that TCE concentrations would be at or below 1 ppb ($\mu\text{g/L}$) in all locations. The Board agrees that 35 years of additional pumping for achieving the small amount of mass removal is not economically feasible." However, if remediation does not show that cleanup is proceeding as the modeling predicts, remediation methods will be revisited.

The CVRWQCB and the U.S. EPA do not concur with the selection of MCLs as the cleanup goal for chloroform and bromodichloromethane, because the MCL for total trihalomethanes is based on the economics of chlorinating a municipal water supply to remove pathogens and therefore does not adequately protect the beneficial uses of a drinking water source that has not been, and may not be, chlorinated. The modeling as described in Appendix E of the GSA Feasibility Study predicts that TCE in the area where chloroform and bromodichloromethane are found will be cleaned up to five to ten parts per billion (ppb) after 55 years of pumping. The agencies predict that this will result in cleanup of chloroform and bromodichloromethane to 1.1 ppb and 0.27 ppb, respectively. If the remediation does not show that cleanup is proceeding as predicted, the cleanup goals for chloroform and bromodichloromethane will be revisited, following the procedure to be outlined in the GSA OU Compliance Monitoring and Contingency Plan.

The CVRWQCB believes that the California Safe Drinking Water and Toxic Enforcement Act of 1986, Health and Safety Code Section 25249.5 et seq. (Proposition 65) is an ARAR for the establishment of *in situ* ground water cleanup levels. DOE has not included Proposition 65 as an ARAR in this ROD because federal agencies are exempt from its requirements (California Health and Safety Code Section 25249.11). The CVRWQCB will not dispute the ROD, however, because the cleanup of the listed constituents will meet or exceed Proposition 65 levels.

Because numerical standards or chemical-specific ARARs for cleanup of contaminants in soil vapor have not been established, DOE and the regulatory agencies agreed upon a cleanup goal for soil vapor which is protective of ground water as discussed in Section 2.9.1.2. The objective is to reduce VOC mass in the vadose zone to levels protective of ground water and remediate VOCs in the vadose zone to the extent technically and economically feasible to minimize further degradation of ground water by contaminants in the vadose zone. DOE, U.S. EPA, and the State disagree on the applicability of SWRCB Resolution No. 92-49 and the CVRWQCB's Water Quality Control Plan with respect to using water quality objectives to establish soil vapor cleanup levels. The State concurs with this ROD, however, because it believes that the standard in Sections 2.9.1.2 and 2.9.3.2 complies with those requirements. This ROD does not resolve the ARAR status of State requirements regarding the establishment of soil cleanup levels.

Chapter 15, CCR Title 23, Sections 2550.7 and 2550.10 are chemical-specific ARARs, which require the monitoring of the effectiveness of remedial actions. In accordance with these ARARs, *in situ* concentrations of VOCs in ground water and soil vapor will be measured during and after the completion of the selected remedy for the GSA OU to monitor its effectiveness in achieving cleanup goals.

State Board Resolution No. 88-63 (Sources of Drinking Water Policy) designates all ground and surface water of the State as drinking water except where the TDS is greater than 3,000 ppm, the water source does not provide sufficient water to supply a single well more than 200 gallons per day, the water is a geothermal resource or in a waste water conveyance facility, or the water cannot reasonably be treated for domestic use using either Best Management Practices or best economically achievable treatment practices.

Chemical-specific ARARs related to the discharges of waste resulting from remediation activities include: 1) the SWRCB Resolution 68-16, which is applicable to the discharge of treated ground water from the remediation systems, and 2) the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) Rules 463.5 and 2201 regulating the discharge of treated vapor. Treated ground water will be discharged according to the requirements of the NPDES Permit (Order No. 91-052) for the eastern GSA and the Substantive Requirements for the central GSA. These permits are administered by the CVRWQCB. The discharge standards under the current permits require that the monthly median VOC concentration in ground water are reduced to below EPA Method detection limits for VOCs (<0.5 µg/L), prior to discharge. Treated vapor will be discharged according to the requirements of the "Authority to Construct" or "Permit to Operate" issued by the SJVUAPCD, which currently requires that VOC concentrations in vapor be treated to 6 ppm_v, prior to discharge to ambient atmosphere.

2.10.2. Location-Specific ARARs

Location-specific ARARs are restrictions placed on the concentration of chemicals or conduct of operations based on the location of a site. Potential location-specific ARARs include the protection of:

- Wetlands.
- Floodplains.
- Historic landmarks.
- Coastal zones.
- Coastal barriers.
- Rare and endangered species.
- Cultural resources.

The GSA does not contain any historic landmarks, coastal zones, or coastal barriers. No wetlands have been identified within the area of the GSA where the remedial action would occur. Although the GSA OU is located adjacent to the 100-year floodplain associated with Corral Hollow Creek, no portion of Site 300 lies within the floodplain. 22 CCR 66264.18(B)(1) states that TSD facilities within a 100-year floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood. If it became necessary to install POU treatment for water-supply well CON-1, which is located offsite within the 100-year floodplain, the system would be constructed in accordance with this requirement.

Archaeological and ecological surveys conducted in the GSA are described in Chapter 6 of the SWRI and the Site 300 EIR/EIS (U.S. DOE, 1992), respectively. Additional surveys to identify potential cultural resources and the presence of sensitive (rare, threatened, or endangered) species will be conducted, as necessary, prior to all ground-breaking activities associated with remediation in the GSA in order to mitigate any adverse impacts of the project. In addition, the discharge of treated water to Corral Hollow Creek that could affect endangered species that may be in the California Department of Fish and Game ecological preserve downstream, is regulated through the NPDES permit for the eastern GSA treatment facility.

2.10.3. Action-Specific ARARs

Action-specific ARARs are usually technology- or activity-based limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. For the selected remedy, there are two action-specific ARARs which are related to: 1) monitoring of the reinjection of treated water, and 2) the management of hazardous wastes generated as a result of remedial activities. All treated water to be reinjected will be analyzed/monitored prior to reinjection in accordance with the requirements of the Safe Drinking Water Act Underground Injection Control Program (40 CFR 144.26-144.27). All hazardous waste generated as the result of the selected remedy, primarily spent GAC, will be handled in accordance with the requirements of CCR, Title 22, Chapter 30 and the Health and Safety Code, Sections 25100-25395.

2.10.4. Other Applicable Standards

There are no ARARs as cleanup standards for contaminants in the vadose zone that may present an inhalation risk to human health. Therefore, a cumulative potential excess cancer risk of 10^{-6} (one in one million) will be used as the cleanup goal for mitigation of VOC inhalation risk inside Building 875 as specified in the NCP (U.S. EPA, 1990a).

As discussed in Section 2.11.2, the selected remedy meets ARARs by actively remediating VOCs in soil and ground water to protect human health and the environment.

2.11. Statutory Determinations

The selected response action for the GSA OU satisfies the mandates of CERCLA Section 121. The remedy will:

- Protect human health by reducing risk from soil vapor inhalation and by achieving ground water remediation goals.
- Comply with ARARs.
- Provide both short- and long-term effectiveness.
- Reduce contaminant toxicity, mobility, or volume as a principal element.
- Be readily implementable.
- Provide the most cost-effective means of achieving remediation goals.

DOE, U.S. EPA, CVRWQCB, and DTSC believe that among the three proposed remedial alternatives, Alternative 3b provides the best balance of trade-offs with respect to the CERCLA evaluation criteria. Site 300 will remain under the control and ownership of DOE for the foreseeable future. This is a major factor in defining the scope of the remedy proposed in this ROD. A brief description of how the selected remedy satisfies each of these statutory requirements, as well as state and community acceptance, is provided below.

2.11.1. Overall Protection of Human Health and the Environment

The selected remedy uses exposure control methods, such as contingency POU treatment and administrative controls, to provide initial protection to human health. It also provides long-term protection to human health by restoring and protecting the beneficial use of the Tnbs₁ regional aquifer and potential beneficial use of the alluvial aquifer through active remediation to reduce VOC concentrations in ground water to MCLs.

The selected remedy prevents potential inhalation of VOCs above health-based concentrations in Building 875 by reducing soil vapor VOC concentrations through soil vapor extraction.

All extracted soil vapor and ground water will be treated before discharge to the environment. Soil vapor and ground water monitoring will document the progress and permanence of all remediation methods.

The selected remedy employs ecological surveys and appropriate response actions, if necessary, to protect the environment. By actively reducing VOC concentrations in soil vapor and ground water, potential future ecological risks are mitigated.

In accordance with a DOE Secretarial Policy issued in June 1994, National Environmental Policy Act (NEPA) values contained in the Environmental Considerations chapter of the GSA FS satisfy the requirements for CERCLA-NEPA integration. As part of these requirements, the potential impacts on the existing onsite and offsite environment due to implementation of the remedial alternatives were evaluated. No significant adverse impacts due to implementation of the alternatives were identified.

2.11.2. Compliance with ARARs

Federal and State chemical-, location-, and action-specific ARARs affecting the selected remedy are described in Table 11. The selected remedy meets all ARARs. Ground water and soil vapor extraction will reduce VOC concentrations to MCLs in ground water in the GSA OU, as well as reduce inhalation risk inside Building 875 to health-protective levels.

2.11.3. Short-Term Effectiveness

The selected remedy immediately protects the public from existing exposure pathways through exposure controls: contingency POU treatment and administrative controls. It also uses ground water and soil vapor extraction to continue to remove VOC mass and reduce VOC concentrations in ground water and soil vapor. It provides measures for the protection of site workers and the community during remedial actions. No adverse environmental impacts are anticipated.

2.11.4. Long-Term Effectiveness and Utilization of Permanent Solutions

The selected remedy provides long-term effectiveness through contaminant mass removal that will: 1) reduce VOC concentrations to MCLs in all affected ground water, and 2) reduce VOC soil vapor concentrations to levels protective of ground water and to acceptable health inhalation risk levels. Monitoring will be continued for five years after discontinuing ground water extraction to ensure long-term effectiveness and permanence.

2.11.5. Reduction of Contaminant Toxicity, Mobility, or Volume as a Principal Element

Contaminant toxicity, mobility, and volume in the soil and ground water will be reduced irreversibly by ground water and soil vapor extraction. In addition, SVE will significantly reduce the toxicity, mobility, and volume of both dissolved and undissolved (DNAPL) contaminants in the subsurface, enhance the progress of VOC removal, and be more protective of the environment than if only ground water extraction was used.

2.11.6. Implementability

The selected remedy can be readily implemented utilizing existing soil vapor and ground water extraction and treatment systems that are permitted and operating in the GSA. Modifications to these systems are readily implementable.

2.11.7. Cost Effectiveness

DOE, U.S. EPA, CVRWQCB, and DTSC agree that Alternative 3b provides the most cost-effective means of remediating VOCs in soil and ground water to levels protective of human health and the environment. The cost of this alternative was estimated on the basis of a preliminary engineering design to reduce inhalation risk, remove VOC mass, and reduce VOC concentrations in ground water to MCLs.

2.11.8. State Acceptance

The California DTSC and CVRWQCB provided ARARs which were used as the basis for developing the selected remedy. These State agencies reviewed and evaluated the remedial technologies and alternatives and participated in the selection of the final remedy and provided oversight and enforcement of state environmental regulations. In addition, the regulatory agencies have monitored and reviewed public acceptance of the final selected remedy.

2.11.9. Community Acceptance

Public comments concerning the selected remedy have been considered and used, as appropriate, in the preparation of this ROD. All public comments are addressed in the Responsiveness Summary section of this document.

Any proposed changes to the ROD, such as the implementation of new remedial alternatives or innovative technologies, re-evaluation of the technical and economic feasibility of achieving cleanup goals, etc., will be submitted to the regulatory agencies for review and approval. Community members will be informed of any ROD change, and would be provided with the opportunity to comment on significant or fundamental ROD changes. Following EPA guidelines (U.S. EPA, 1991), the lead agency determines if the proposed ROD change is: 1) nonsignificant or minor, 2) significant, or 3) fundamental.

3. Responsiveness Summary

This section responds to public comments directed to DOE, LLNL, U.S. EPA, and the State of California regarding the Proposed Plan for remediation of the GSA OU. Responses to community comments and concerns are incorporated into this ROD.

The public comment period on the Proposed Plan began April 10, 1996, and ended May 10, 1996. On April 24, 1996, DOE/LLNL and the regulatory agencies held a public meeting at the Tracy Inn in Tracy, California to present the proposed remediation plan and allow the public to ask questions and comment on the preferred remedial alternative. Representatives from LLNL summarized the information presented in the FS and Proposed Plan. Following the presentation, three members of the public read their concerns into the formal public record. Although no letters were received during the Proposed Plan comment period, members of the Tri-Valley Citizens Against a Radioactive Environment (CAREs) provided a written record of their meeting comments. The meeting transcript and a copy of the written concerns are available to the public at the LLNL Visitors Center and the Tracy Public Library.

3.1. Organization of the Responsiveness Summary

This Responsiveness Summary is organized to clearly present the breadth of public concerns while minimizing repetition. In keeping with EPA Superfund guidance and accepted practice, comments are grouped by subject. Whenever possible, comments are summarized verbatim from either the meeting transcript or written comments.

Public comments are grouped into the following sections:

- Selected Remedial Action.
- General Comments.

3.2. Summary of Public Comments and Responses

3.2.1. Selected Remedial Action

Comment 1:

Before the Proposed Plan is approved, it is important that the monitoring plan be specified, (number of wells, depth of wells, frequency of sampling, duration of sampling, approximate location of wells) and that a contingency plan be specified which delineates what the Lab is committed to do should it find that the plume is moving, or is not being remediated in the time-frame expected. This should be similar in content to the way contingency was addressed in the document entitled "Remedial Alternatives for the Building 815 Operable Unit." There, specific information regarding what the Lab was prepared to do if the plume migrated past a certain point was established.

Response to Comment No. 1:

A preliminary monitoring plan was presented in the FS to support cost estimates for each remedial alternative. This preliminary monitoring plan presented the number of wells and the frequency and duration of sampling. The depths and approximate locations of these wells were also included in the FS. This information was not reiterated in the Proposed Plan, which is intended to be a brief summary document. Consistent with EPA guidance and practice at other U.S. EPA Superfund sites, the GSA monitoring program will be presented in the Remedial Design document. As specified in the Site 300 FFA, a discussion of the schedule for the Remedial Design for the GSA will be initiated within 15 days of the signing of the Final ROD, which is scheduled for January 1997.

A formal review of remediation progress is required to be conducted at least every five years to ensure that the selected remedy is effective and continues to adequately protect human health and the environment. However, the evaluation of the progress of remediation will be an on-going, continuous process. Progress of site cleanup will be published in periodic progress reports. If monitoring data indicate that the selected remedy is not effectively remediating the site, DOE/LLNL and the regulatory agencies will evaluate whether to consider another remedial alternative.

Comment 2:

The plan should contain milestones by which the success of the subsequent remediation can be evaluated. In almost all Superfund cleanup projects, commitments and milestones concerning the cleanup performance (e.g., timing of cleanup, how much contaminant will be removed) are disregarded in Records of Decision. We regard this as a fundamental problem with the government's approach to CERCLA enforcement. For example, we suggest that a timetable for cleanup be established. This could be based on performance milestones such as the amount of contaminant mass that is removed from the soil and groundwater within an expected time period, and regulatory milestones such as achieving cleanup standards or showing a trend towards meeting cleanup standards. This timetable would then be used to monitor the performance of cleanup, and provide interested parties with some idea how cleanup will progress. As it now stands, after a final ROD is signed, the only legal requirements are that substantial on-site remedial action be commenced within 15 months and that the cleanup program be subject to a five-year review. It is important that the Proposed Plan contain a measurable schedule and performance standards which can be verified.

Response to Comment No. 2:

Consistent with U.S. EPA Superfund guidance and as specified by the CERCLA process, schedules and performance milestones will be presented in the GSA Remedial Design document. As specified in the Site 300 FFA, a discussion of the schedule for the Remedial Design document for the GSA will be initiated within 15 days of the signing of the ROD, which is scheduled for January 1997.

DOE will make the Remedial Design document available to the public as part of the CERCLA public participation process. The public will have an opportunity to review and

comment on the Remedial Design document. If concerns or issues concerning the Remedial Design document are identified on the part of the public and regulatory agencies, a public meeting may be considered.

The Remedial Design document will define in detail the technical parameters, design criteria and components, and assumptions of the Remedial Action including:

1. Waste characterization,
2. Pretreatment requirements,
3. Volume and types of each medium requiring treatment,
4. Treatment schemes, rates, and required qualities of waste water streams,
5. Performance standards,
6. Long-term performance monitoring and O&M requirements,
7. Compliance with all ARARs, codes, and standards,
8. Technical factors of importance to the design and construction,
9. Construction schedule,
10. Cost estimates,
11. Variances with the ROD, if necessary,
12. Land acquisition and easement requirements, and
13. Value Engineering Screening (including an evaluation of cost and function relationships, concentrating on high-cost areas.

The final Remedial Design must be approved by the regulatory agencies before initiating the Remedial Action. Cleanup standards are included in Section 2.9.1 of this ROD.

A formal review of remediation progress is required to be conducted at least every five years to ensure that the selected remedy is effective and continues to adequately protect human health and the environment. However, the evaluation of the progress of remediation will be an on-going, continuous process.

If the selected remedy fails to meet the criteria set forth in the design documents, DOE/LLNL and the regulatory agencies will evaluate whether to consider another remedial alternative.

Comment 3:

I want to emphasize the need for contaminant reduction milestones as a method of determining not only how well the cleanup is doing, but whether or not the cleanup's budget year to year is sufficient. Right now, and this is a problem we are running into at the Main Site to some extent, and in other sites as well, where the milestones are defined as production of documents, we are going to have a remedial design document by thus and such a date or the milestone is the putting in of a monitoring well or the construction of an extraction well irrespective of whether those things alone. Well obviously the production of the document

doesn't actually remediate the site, irrespective of whether those things alone together are going to accomplish the cleanup and keep it on schedule.

In saying you have a 55-year cleanup time, somebody has done a curve. I mean, you are figuring you are going to peg down the contaminant levels by certain amounts to get to cleanup in 55 years. If you made them explicit, that would give the citizens a way to track how the cleanup is doing, say, in five-year increments and that the cleanup was falling behind, we would then have something we could use in saying our community needs some more money to get this back on track. None of us wants to wait 55 years, which means our children and in some cases our children's children will then say oh, that wasn't enough, it isn't cleaned up.

So we really (the public) need this stuff to be codified in the Record of Decision to help watch dog and ensure a full cleanup. As Peter mentioned, mass removal milestones is another entree into the same type of result.

Response to Comment No. 3:

As stated in the response to Comment 2, schedules and performance milestones will be presented in the design document; consistent with U.S. EPA Superfund guidance and as specified by the CERCLA process. Budgetary issues are discussed in the response to Comment 17.

The 55-year projected time to reduce VOC ground water concentrations in the central GSA to MCLs was based on remediation and contaminant fate and transport modeling presented in the GSA FS. The modeling for the selected remedy (Alternative 3b) was discussed in Section E-2.9.2.2 of the FS, and presented simulated VOC ground water concentrations for 10, 30, 55, and 90 years after initiation of remediation.

The modeling indicated that the selected remedy utilized the optimum number and configuration of extraction wells for the most cost- and time-effective remediation of the GSA. Although this modeling was conducted primarily for the purposes of determining cost, it estimates remediation progress. Additional modeling using current data may be conducted during the five-year review to evaluate remediation progress.

Comment 4:

The Proposed Plan or the ROD should identify criteria it will use to determine whether a remedy should be replaced with a new remedy, or that remediation should be discontinued. In the case of the former, there are many new development activities which may improve upon the selected remedy. At some time in the future there may be a decision to replace old technology. The (Proposed Plan) or the ROD should outline what decision criteria will be used to re-assess the proposed technology. In addition, there has been a trend at some sites to stop remediation on the grounds of "Technical Impracticability". The (Proposed Plan) or the ROD should outline the decision criteria that would be used to make such a determination, as the decision will not be subject to the same level of public scrutiny as is the ROD.

Response to Comment No. 4:

The decision criteria that will be used to determine:

1. When remediation should be discontinued are discussed in Section 2.9.3 of the ROD.
2. Whether to replace the technologies outlined in the ROD are discussed in Section 2.9.4 of the ROD.
3. When to cease remediation activities based on Technical Impracticability are discussed in Section 2.9.3 of the ROD.

U.S. EPA's OSWER Directive 9234.2-25, "Guidance for Evaluating the Technical Impracticability of Ground Water Restoration" (EPA, 1993c), provides guidance for evaluating Technical Impracticability. If the cleanup levels are changed due to Technical Impracticability, an ARARs waiver will be obtained and a ROD amendment will be necessary.

Throughout the remediation process, innovative remediation technologies will be considered to enhance VOC mass removal and treatment of soil vapor, as discussed in Section 2.9.4.

In addition, a review will be conducted every five years after commencement of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

Comment 5:

If the Proposed Plan could contain some more detail about the types of treatment technologies that are being considered, a little bit of data on the effectiveness of the treatment technologies being used as pilot projects so that we could then discuss in greater detail, what kind of suite of treatment technologies we might want to codify in the Record of Decision. That would make for a much higher sort of level of decision.

Response to Comment No. 5:

The types of treatment technologies considered for implementation at the GSA, including the technologies included in the selected remedy, were screened and discussed in detail in the GSA FS. The effectiveness of the existing treatment systems was also evaluated and discussed in the GSA FS. The Proposed Plan is designed to be a brief summary of the major components of the evaluated alternatives and the preferred remedy that are discussed in detail in the FS.

Comment 6:

The criteria for choosing treatment technologies need to be a part of the Record of Decision.

Response to Comment No. 6:

Consistent with U.S. EPA Superfund guidance, the criteria for choosing treatment technologies was presented in the GSA FS, where each treatment technology was screened and discussed. See also response to Comment No. 3.

Comment 7:

Remedial action objectives should be identified in the Proposed Plan and include:

- i) Protect human health and ecological receptors from contact with contaminated groundwater, soil or air;*
- ii) Attain the preliminary remediation goals (PRGs) set by EPA Region 9. (PRGs are remediation goals with an estimated health risk of one in one million additional cancer deaths);*
- iii) Conduct cleanup in such a way as to minimize time for remediation;*
- iv) In the Central GSA, continue efforts to remove contaminant mass from the ground water and soil and locate the source of dense non-aqueous phase liquid (DNAPL).*

Response to Comment No. 7:

- i) Section 2.5 of the FS defines Remedial Action Objectives (RAOs) which are media-specific goals for protecting human health and the environment. EPA guidance indicates that RAOs are to specify exposure routes for which potentially unacceptable risk has been identified, contaminants of concern, and an acceptable contaminant concentration or range of concentrations. We have addressed these points in the RAOs. Cleanup goals are discussed in Chapter 4 of the FS and are specified in more detail in Section 2.9.1 of this ROD.
- ii) The U.S. EPA, and the State DTSC, and CVRWQCB have concurred with a cleanup goal of MCLs for VOCs in ground water in the GSA OU. The CVRWQCB's decision to concur with MCLs as ground water cleanup goals was based on technical and economic information in the Final FS for the GSA OU. The CVRWQCB stated "LLNL/DOE presented costs and time needed to cleanup to MCLs and nondetectable for TCE. Based on numerical fate and transport modeling, LLNL/DOE showed that concentrations of TCE would be below the limit of detection (0.5 ppb [$\mu\text{g/L}$]) in all but a 12-acre area in the vicinity of the GSA after 55 years of pumping. The 12-acre area would be below the MCLs, except for an approximately 100 ft-square area at 5 to 10 ppb ($\mu\text{g/L}$). Simulation TCE fate and transport for an additional 35 years (without pumping) showed TCE contamination at or below 1 ppb ($\mu\text{g/L}$) except for about a 100 ft-square area, which would be at or below the MCL. LLNL/DOE also simulate 90 years of pumping, which showed that TCE concentrations would be at or below 1 ppb ($\mu\text{g/L}$) in all locations. The Board agrees that 35 years of additional pumping for achieving the small amount of mass removal is not economically feasible. However, LLNL/DOE will be required to review the remedial system every five years to determine if the remedial objectives are being

met. LLNL/DOE will optimize the system or propose an alternative remedial method if the plume is not being remediated as projected.”

MCLs are health based and equivalent to an excess cancer risk of 10^{-6} , or one in one million, with consideration given to technologic and economic factors. U.S. EPA Region IX Preliminary Remediation Goals, according to EPA, “can be used as a rapid reference for screening concentrations in environmental media, as ‘triggers’ for further investigation at CERCLA/RCRA sites, and as initial cleanup goals, if applicable.” The NCP (U.S. EPA, 1990a) states that “PRGs should be modified, as necessary, as more information becomes available during the RI/FS. Final remediation goals will be determined when the remedy is selected.” Remediation goals are developed by considering ARARs under Federal or State environmental laws. The NCP also states that the “ 10^{-6} risk level shall be used as the point-of-departure for determining remediation goals for alternatives when ARARs are not available.”

- iii) The preferred remedy is designed to achieve soil and ground water cleanup goals in a time-effective manner using proven, implementable technologies. Other remediation scenarios were evaluated, such as installing more wells to determine if an increased ground water extraction rate would expedite cleanup. Modeling indicated that the selected remedy provided the most expeditious, cost-effective means of remediating the GSA OU.
- iv) The selected remedy (Alternative 3b) includes both ground water and soil vapor extraction to remove contaminant mass from ground water and soil in the central GSA. Based on historical and sampling data, DNAPLs may be present in the vicinity of the Building 875 dry well pad where the SVE remediation efforts are concentrated. The only wells in the GSA where ground water sample data indicate the possible presence of DNAPLs (TCE concentrations $>11,000$ ppb) are wells W-875-07, -08, -09, -10, -11, -15, and W-7I. These wells are all located in the Building 875 dry well pad area in the central GSA. The source of DNAPLs in this area was the wastewater disposed in the two former dry wells, 875-S1 and 875-S2, located south of Building 875. No other wells in the GSA have contained VOCs in ground water in concentrations indicative of DNAPLs, including wells located at other source areas. We have therefore concluded that the DNAPLs are confined to the Building 875 dry well pad area in the central GSA. SVE has been identified as a technology that can effectively remediate DNAPLs in the vadose zone.

Throughout the life of the remediation project, continued efforts will be made to evaluate whether DNAPLs act as a continuing source of contamination. The methodology and schedule for the evaluation of DNAPLs will be included in the remedial design document. The objective of these investigations is to validate whether the assessment of the location of DNAPLs, as well as efforts to remediate DNAPLs, are properly focused.

Comment 8:

The Proposed Plan should include a continued search for the location of DNAPLs in the central GSA, and the testing and/or development of new technologies to extract DNAPL, until monitoring conclusively proves that they are no longer present in the area. It does not appear that the DNAPL problem will be solved by the Proposed Plan. Without removal of DNAPL, the

site will act as a continuing source of contamination, and may reverse the progress that has been made in cleanup over the past several years. While DNAPL or potential DNAPL exists at many sites that I am aware of, solutions are elusive without knowing the precise location. I suggest the (Proposed Plan) identify how many quarters (or years) that monitoring will be required to show that DNAPLs are no longer present.

Response to Comment No. 8:

As discussed in Chapters 1 and 4 of the FS, residual DNAPLs may exist in soil in the dewatered zone and/or vadose zone in the central GSA in the vicinity of the Building 875 dry well pad, as discussed in the response to Comment No. 7 (iv). Data from other nearby wells and wells in other source areas allows us to conclude that DNAPLs are confined to the Building 875 dry well area.

The preferred remedy (Alternative 3b) includes SVE, which has been identified as a technology that can effectively remediate DNAPLs in the vadose zone (U.S. EPA, 1992d, 1993b). Historical sampling data indicate that DNAPLs may be in the vicinity of the Building 875 dry well pad where the SVE remediation efforts are concentrated. Ground water, soil, and soil vapor data collected from other release areas do not indicate that DNAPLs are present. DOE/LLNL will continue to investigate and evaluate innovative technologies that may be considered for application at the GSA if they could be implemented cost effectively and expedite remediation. Throughout the life of the remediation project, continued efforts will be made to evaluate whether DNAPLs act as a continuing source of contamination. The methodology and schedule for the evaluation of DNAPLs will be included in the remedial design document. The objective of these investigations is to validate whether the assessment of the location of DNAPLs, as well as efforts to remediate DNAPLs, are properly focused.

In general, if a ground water VOC concentration is 1 to 10% of the solubility of that VOC in ground water, then a DNAPL may be present. Because the aqueous solubility of TCE is 1,100,000 µg/L, TCE concentrations in the range of 11,000 to 110,000 µg/L or greater would indicate DNAPL. The cleanup goals established for ground water (i.e., 5 µg/L for TCE) are well below the concentrations indicative of DNAPLs (11,000 µg/L for TCE). When VOC concentrations in ground water have been reduced to cleanup goals (MCLs), the ground water extraction and treatment system(s) will be shut off and placed on stand-by. Modeling indicates that VOC concentrations in ground water in the central GSA should be reduced to MCLs within 55 years following the initiation of remediation. Ground water in the central GSA will continue to be monitored for a period of five years following shutdown of the system. This will allow tracking of ground water VOC concentration trends in the Building 875 dry well pad area to determine if: 1) ground water VOC concentrations in the area indicate DNAPLs, and 2) the ground water remediation goal has been attained and maintained. Should VOC concentrations in ground water “rebound” or increase above cleanup goals, reinitiation of remediation efforts will be discussed with the regulatory agencies.

Comment 9:

I am concerned on a number of levels. One of them, let me just use as an example the problem with dense non-aqueous phase liquids with the concentrations of TCE that you have at

Site 300, there probably are globs of pure TCE in there and as those dissolve over time it is going to continue as its own source of contamination and in order to get at those, you guys need money for something called source investigation. John Ziagos will remember I am big on advocating money for source investigation to make sure that you have got the information you need so that you put in the right cleanup technologies in the right places to actually achieve a cleanup. I think it's penny wise and pound foolish to neglect source investigation, so I am looking at the Department of Energy's fiscal year 1998 draft priority list and for the one that's for the Livermore Lab Main Site and Site 300. The first time I see source investigation, let me just say for the record, this line here is put at a target of what is gonna be 19.4 million dollars they plan to ask for for FY 1998 and everything that falls below this line they are not even gonna ask for money for and the first time source investigation is mentioned is about ten listings below the line. So, there is not even any consideration that DOE is going to even ask for money that will adequately fund source investigation in the time frame when you are really gonna need that money. So codifying something in the Record of Decision is a way to ensure that that gets bumped up, because then it becomes a legal requirement and it suddenly is part of what becomes necessary and not optional and in my opinion, some of these things, I mean, all of these that I am talking about are necessary.

So then I looked at how it rates in the field office where the lab has to compete against the other DOE facilities and its four from the bottom on page 5. So if it isn't codified in the Record of Decision, I kind of think that you are probably not gonna get the money to do it and you are going to have ongoing problems that will threaten the entire cleanup because there is not the money to go out and do the source investigation needed to fund the DNAPLs and also some of the other important parameters before cleanup can be accomplished.

Response to Comment No. 9:

Based on historical sampling data described in the response to Comment No. 7 (iv) and our extensive source investigations presented in the SWRI and FS, we have concluded that DNAPLs are confined to the Building 875 dry well pad area in the central GSA. The source of potential DNAPLs in this area was the wastewater disposed in the two former dry wells 875-S1 and 875-S2 located south of Building 875. No other wells in the GSA have contained VOCs in ground water indicative of the presence of DNAPLs. Because the source of the DNAPLs has been confirmed as the two former dry wells 875-S1 and 875-S2, located south of Building 875, and analytical data confirms that the DNAPLs are confined to the vicinity of the Building 875 dry well pad, no additional source investigation for DNAPLs in the GSA is planned at this time. TCE concentrations in ground water in GSA monitor wells will be monitored throughout the life of remediation. If future ground water analytic data indicate that DNAPLs have migrated or are present in other areas of the GSA, changes to the remediation system(s) to address the presence/remediation of DNAPLs will be considered at that time.

Throughout the life of the remediation project, continued efforts will be made to evaluate whether DNAPLs act as a continuing source of contamination. The methodology and schedule for the evaluation of DNAPLs will be included in the remedial design document. The objective of these investigations is to validate whether the assessment of the location of DNAPLs, as well as efforts to remediate DNAPLs, are properly focused.

Comment 10:

I think essentially the points that both Peter Strauss and Marylia Kelly have made about looking for these DNAPLs, as they are called, looking for the source of contamination which obviously could have an impact on the cleanup and how fast or how easy it would be to achieve certain milestones, which I do believe should be in place, are critical.

Response to Comment No. 10:

See responses to Comments Nos. 7 (iv) and 9. The potential presence of DNAPLs in the central GSA was factored into the ground water modeling conducted for the selected remedy. This modeling was the basis for estimating cleanup time for the selected remedy.

Comment 11:

The Lab must demonstrate that natural attenuation is actually occurring at this OU. At the main site, early modeling factored in natural attenuation to calculate cleanup time. A later study invalidated this assumption. There has not been, to the best of my knowledge, conclusive evidence that natural attenuation is a relevant factor in the cleanup of TCE at Site 300, although models on the length of time for cleanup may use this assumption. For example, vinyl chloride is a natural breakdown product of TCE. TCE has been found at extremely high concentrations in the GSA, yet the baseline health risk assessment does not include an assessment of vinyl chloride because it has not been found at Site 300. Vinyl chloride is a known human carcinogen, and is harmful at very low concentrations, i.e., 0.5 ppb is the drinking water standard for vinyl chloride.

Response to Comment No. 11:

The selected remedy (Alternative 3b) does not rely on natural attenuation as a component of the remediation of soil or ground water in the GSA. This remedy provides for active remediation to reduce VOC concentrations in soil and ground water to levels protective of human health and the environment.

Comment 12:

Something that our group, working with a hydrologist, took a look at for the Main Site cleanup which you will recall, John Ziagos, but I would like to see you folks take a crack at this for the GSA and that is taking a look at, okay, you have a cost estimate in present dollars. What percentage of that is your capital costs and what percentage is M&O costs? How many extraction wells, etc. do you plan to put in? How many could you put in optimally and if so, how would that cut down on your 55-year cleanup time and, therefore, perhaps really cut down on the amount of cost for the cleanup overall? If it became a 30-year cleanup with some more extraction wells instead of a 55-year cleanup, perhaps the overall cost would go down dramatically. I suspect that that's true. Again, this is information, that if it were discussed and

analyzed in your documents, you could pick up some allies in the citizens groups in terms of helping implement what DOE calls the accelerated cleanup.

Response to Comment No. 12:

Capital costs represent 18% of the total cost for implementing the selected remedy, while the operation and maintenance (O&M) costs are 30% of the total. The other 52% consists of monitoring and contingency (POU treatment, etc.) costs. These percentages for the proposed alternatives, as well as the selected remedy, are shown in Figure 5-1 of the FS.

The number of extraction wells proposed for the selected remedy is discussed in Section 2.9 of this ROD. The number and location of these extraction wells were based on modeling that was used, in part, to determine the optimum configuration and number of extraction wells for the most cost- and time-effective removal of VOCs from the GSA. The modeling indicated that increasing the number of extraction wells, from the number currently proposed, would not significantly decrease cleanup time. However, these modeling data will be evaluated and incorporated into the final design presented in the Remedial Design document. Data obtained from future well installation may allow DOE/LLNL to optimize wellfield performance.

Comment 13:

I wanted just to emphasize a little bit aside from agreeing on the need for real milestones in achievement in cleanup which should be built in, I am particularly concerned about the budgetary aspects of this, and it occurred to me also that, as Marylia Kelly pointed out, really 3b was the only truly legal alternative and I am very pleased that the lab is, you know, proceeding forth on that track; but, if you were to consider alternatives among legal alternatives, you might be looking at alternatives with different time schedules and that, of course, also may have different budget schedules, you know, the 55-year schedule versus a 30-year or whatever and what different amount of technology that needs to be put in at the front end of that and what kind of schedule you have.

Response to Comment No. 13:

As part of the modeling conducted to estimate cleanup times, various numbers of extraction wells were evaluated to estimate the optimum configuration and number of extraction wells to achieve the most time- and cost-effective cleanup of the GSA. The optimum configuration and number was included in the ground water extraction component of the selected remedy (Alternative 3b). The modeling indicated that by increasing the number of extraction wells from that presented in the selected remedy, the time and cost of cleanup were not significantly decreased. Numerous remedial technologies were evaluated and screened as part of the GSA FS. The technologies in the selected remedy represent the best available technologies, given site conditions, currently available. DOE/LLNL will continue to evaluate innovative technologies for possible use in the GSA if innovative technologies will expedite site cleanup and/or be more cost effective.

Comment 14:

The cleanup standards for TCE and other VOCs should be more stringent. Because the GSA connects with the regional aquifer, we believe that the cleanup standard should be set at the incremental lifetime cancer risk (ILCR) of one in one million (1×10^{-6}). CERCLA guidelines require cleanup to 1×10^{-4} to 1×10^{-6} ILCR. The Preliminary Remediation Goal (PRG) for TCE is the most current attempt to define the 1×10^{-6} cleanup standard. The PRG for TCE is 1.8 ppb. We believe that PRGs should be adopted for VOCs that can migrate to the regional aquifer. I note that at two other Superfund sites where I serve as the Technical Advisor, the PRPs (in one case a private party, in another the DoD and the City of Tucson) have adopted a cleanup standard based on reducing risk to one in one million. Thus, it is clear that EPA and responsible parties can adopt these stricter standards.

Response to Comment No. 14:

The U.S. EPA, and the State DTSC, and CVRWQCB have concurred with a cleanup goal of MCLs for VOCs in ground water in the GSA OU. The CVRWQCB's decision to concur with MCLs as ground water cleanup goals was based on technical and economic information in the Final FS for the GSA OU. The CVRWQCB stated "LLNL/DOE presented costs and time needed to clean up to MCLs and non-detectable TCE. Based on numerical fate and transport modeling, LLNL/DOE showed that concentrations of TCE would be below the limit of detection (0.5 ppb [$\mu\text{g/L}$]) in all but a 12-acre area in the vicinity of the GSA after 55 years of pumping. The 12-acre area would be below the MCLs, except for an approximately 100 ft-square area at 5 to 10 ppb ($\mu\text{g/L}$). Simulation TCE fate and transport for an additional 35 years (without pumping) showed TCE contamination at or below 1 ppb ($\mu\text{g/L}$) except for about a 100 ft-square area, which would be at or below the MCL. LLNL/DOE also simulate 90 years of pumping, which showed that TCE concentrations would be at or below 1 ppb ($\mu\text{g/L}$) in all locations. The Board agrees that 35 years of additional pumping for achieving the small amount of mass removal is not economically feasible. However, LLNL/DOE will be required to review the remedial system every five years to determine if the remedial objectives are being met. LLNL/DOE will optimize the system or propose an alternative remedial method if the plume is not being remediated as projected."

MCLs are health based and equivalent to an excess cancer risk of 10^{-6} , or one in one million, with consideration given to technologic and economic factors. U.S. EPA Region IX Preliminary Remediation Goals, according to EPA, "can be used as a rapid reference for screening concentrations in environmental media, as 'triggers' for further investigation at CERCLA/RCRA sites, and as initial cleanup goals, if applicable." The NCP (U.S. EPA, 1990a) states that "PRGs should be modified, as necessary, as more information becomes available during the RI/FS. Final remediation goals will be determined when the remedy is selected." Remediation goals are developed by considering ARARs under Federal or State environmental laws. The NCP also states that the " 10^{-6} risk level shall be used as the point-of-departure for determining remediation goals for alternatives when ARARs are not available."

3.2.2. General Comments

Comment 15:

Also, as a general comment, I would like to say that for each of the areas of Site 300, the DOE and the lab and the regulators would do well to interface with the DOE folks who are preparing the waste management programmatic environmental impact statement which gives as one of the potential alternatives, the burial of large amounts of ash from mixed waste and low level radioactive waste at Site 300 and how that potential burial of waste would impact the cleanup is something that they didn't look at in the waste management PEIS and that was one of our comments on that, but it's also something that you then can't incorporate in talking about the cleanup of these various operable units because, in fact, they didn't even mention where they planned to dump it at Site 300. So for each of these, that is a question for you guys to ask and get some clarification, and if you don't think dumping a lot of radioactive and still possibly toxic ash is going to aid the cleanup, you might have some allies in the citizens group on that.

Response to Comment No. 15:

Comment noted.

Comment 16:

One last overarching issue, and there is no delicate way to bring it up so I will just bring it up bluntly. Our group is really concerned about some of the changes that are being considered in the Superfund laws and in particular, some of the changes that would affect the Livermore lab cleanup wherein if the state standard was stricter than the federal standard, the federal standard would become the only thing that the lab would have to clean up to. There are a number of areas where the Regional Water Quality Control Board and the state DTSC have stricter standards than the federal EPA and achieving those standards is an important part of achieving an actual cleanup and so what I think should be investigated is the extent to which writing those things in the Record of Decision will be one way of protecting against having the standards be lowered as the cleanup goes on, and as we all know, once the standards change, the Departments of Energy's target changes and so that target, in terms of how clean is clean and what they think they need to clean up to is in danger of becoming lower and lower and the Record of Decision is the method that I see to ensure that today's cleanup standards are the cleanup standard's that are met.

Response to Comment No. 16:

If Federal or State regulations were to change in the future, DOE and the regulatory agencies would discuss how these changes might affect cleanup. The community would be informed of any regulatory changes that affect cleanup at Site 300. Any proposed changes to the ROD must be submitted to the regulatory agencies for review and approval. Following EPA guidelines (U.S. EPA, 1991), the lead agency determines if the proposed ROD change is: 1) nonsignificant

or minor, 2) significant, or 3) fundamental. Community members would be informed of any ROD change, and would be provided with the opportunity to comment on significant or fundamental ROD changes.

Comment 17:

Our group has talked a number of times of the need for stable long-term funding and budget commitments. Having some kind of budget schedule for the preferred alternative and any other alternative time scenarios would be very useful for citizens to be able to monitor the commitment of the DOE and the lab to the cleanup as well as in combination with achievement milestones and whether they are on track with that, whether the funding is adequate and so I would argue for some kind of additional information to be included on the budgetary aspect over time.

Response to Comment No. 17:

DOE cannot legally commit to funding cleanup or any other activities beyond the current budget year appropriation. However, DOE places a high priority on risk reduction, compliance, and associated environmental cleanup in its annual budget submittals. DOE understands that cleanup delays will likely increase the overall cost of the LLNL cleanup as well as other facilities, so it is in DOE's best interest to support an adequately funded and progressive cleanup effort through its annual Congressional budget request each year. DOE does commit to request from Congress, through the Office of Management and Budget, funding necessary to control and remediate contaminant plumes, both on and offsite. In addition, DOE is also committed to removing contaminants as efficiently as possible using available technologies within budgeting allocations.

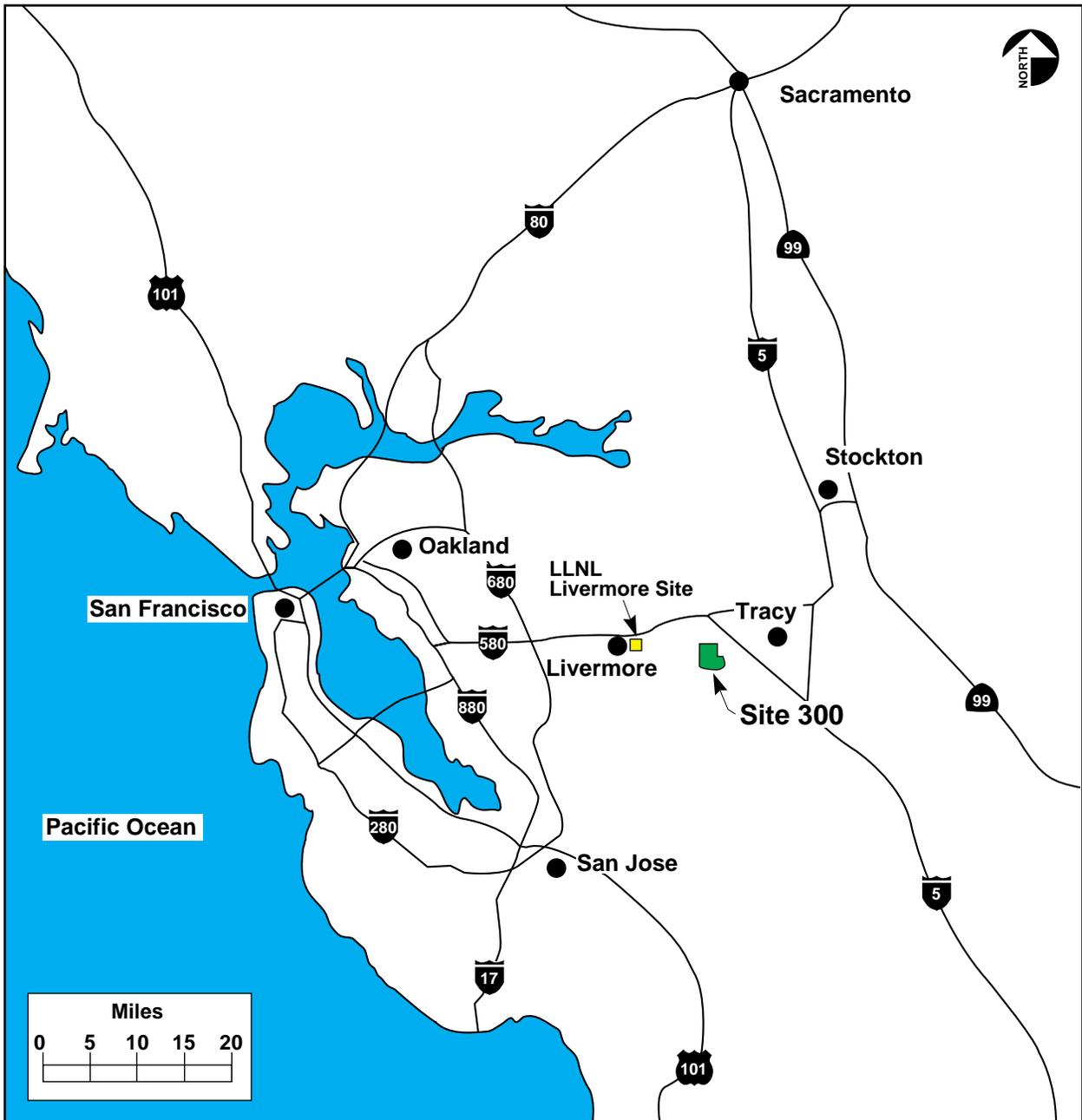
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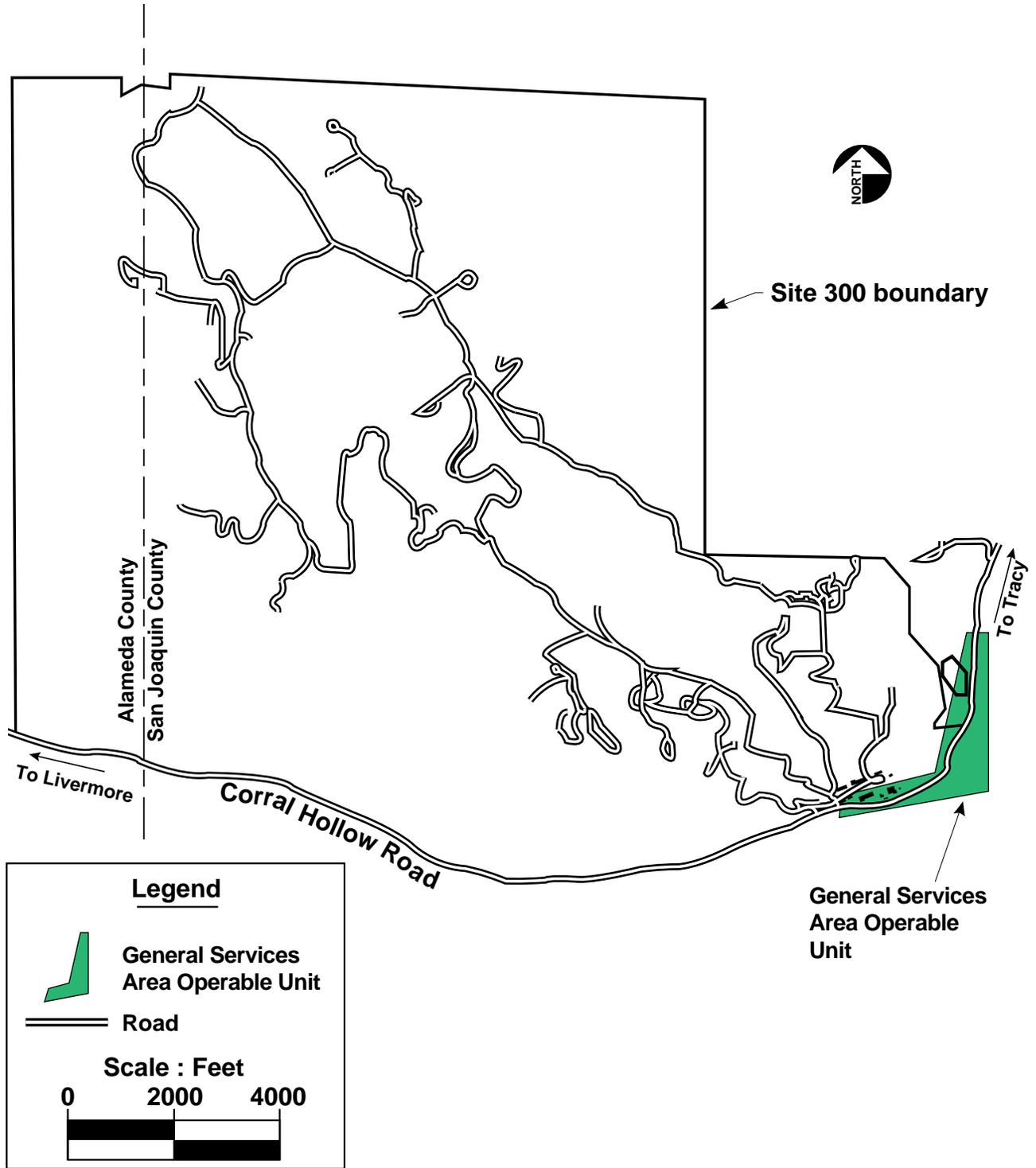
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Figures



ERD-GSA-ROD-0001

Figure 1. Locations of LLNL Livermore Site and Site 300.



ERD-GSA-ROD-0002

Figure 2. Location of the General Services Area OU at LLNL Site 300.

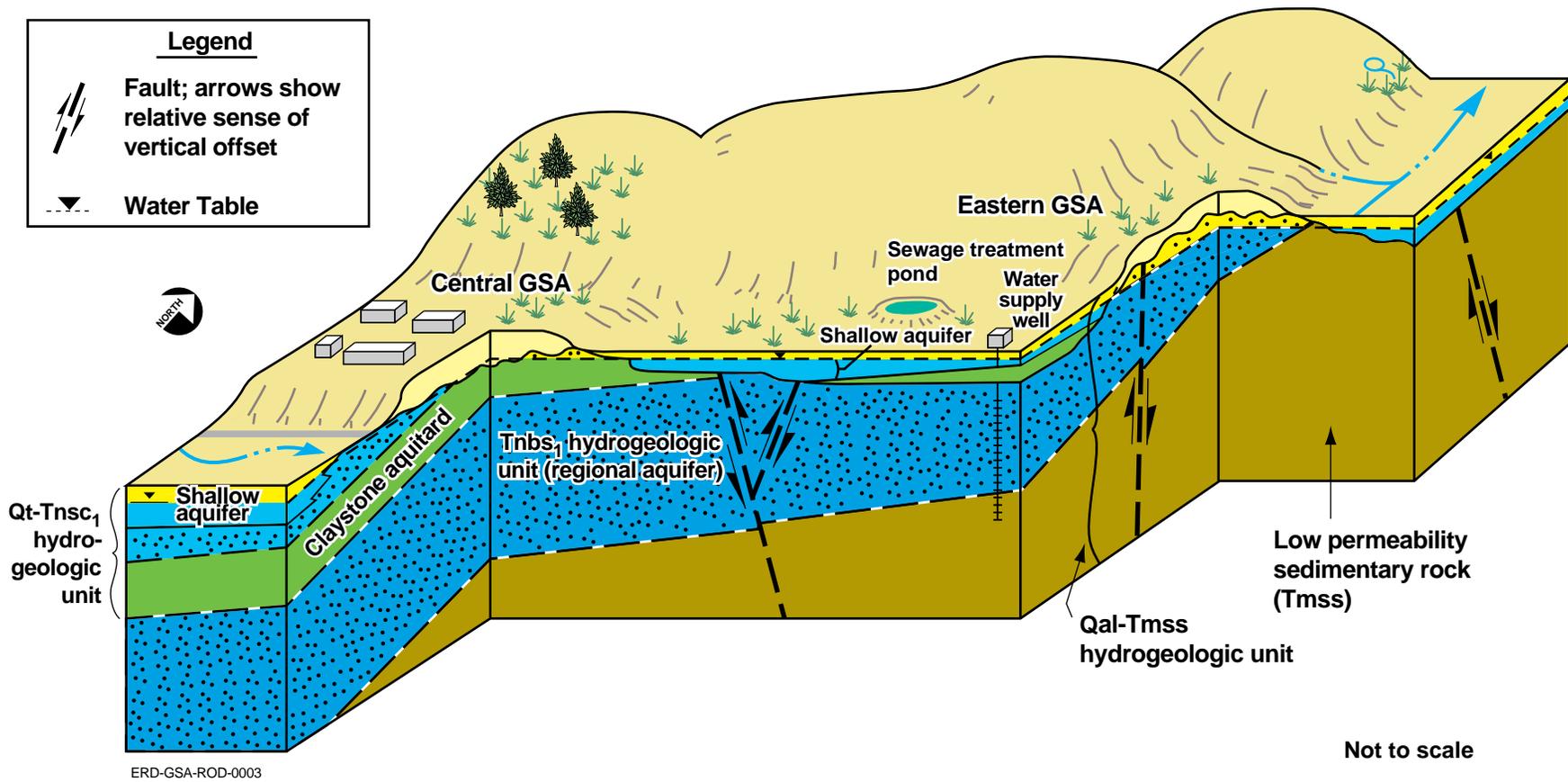
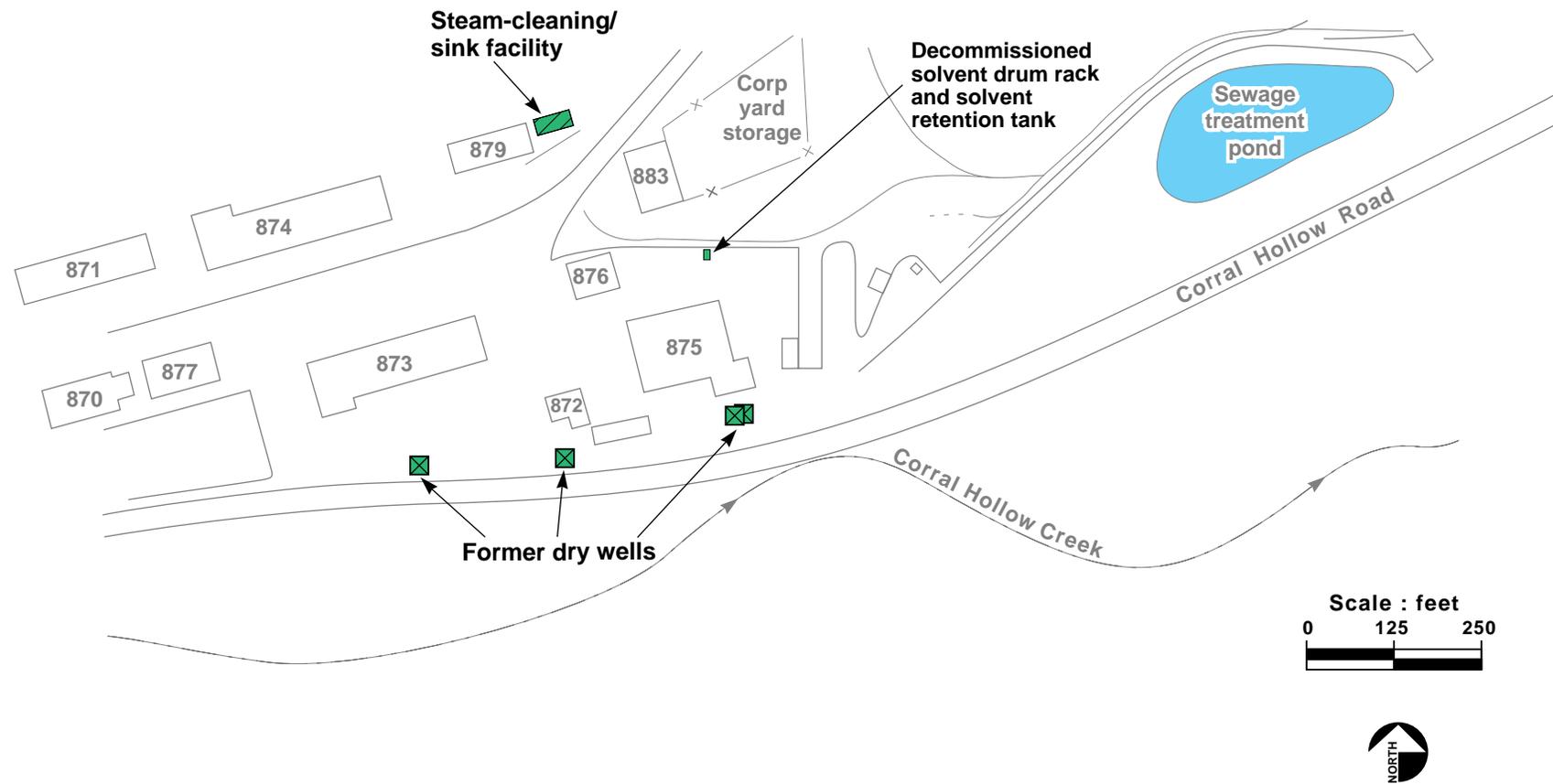
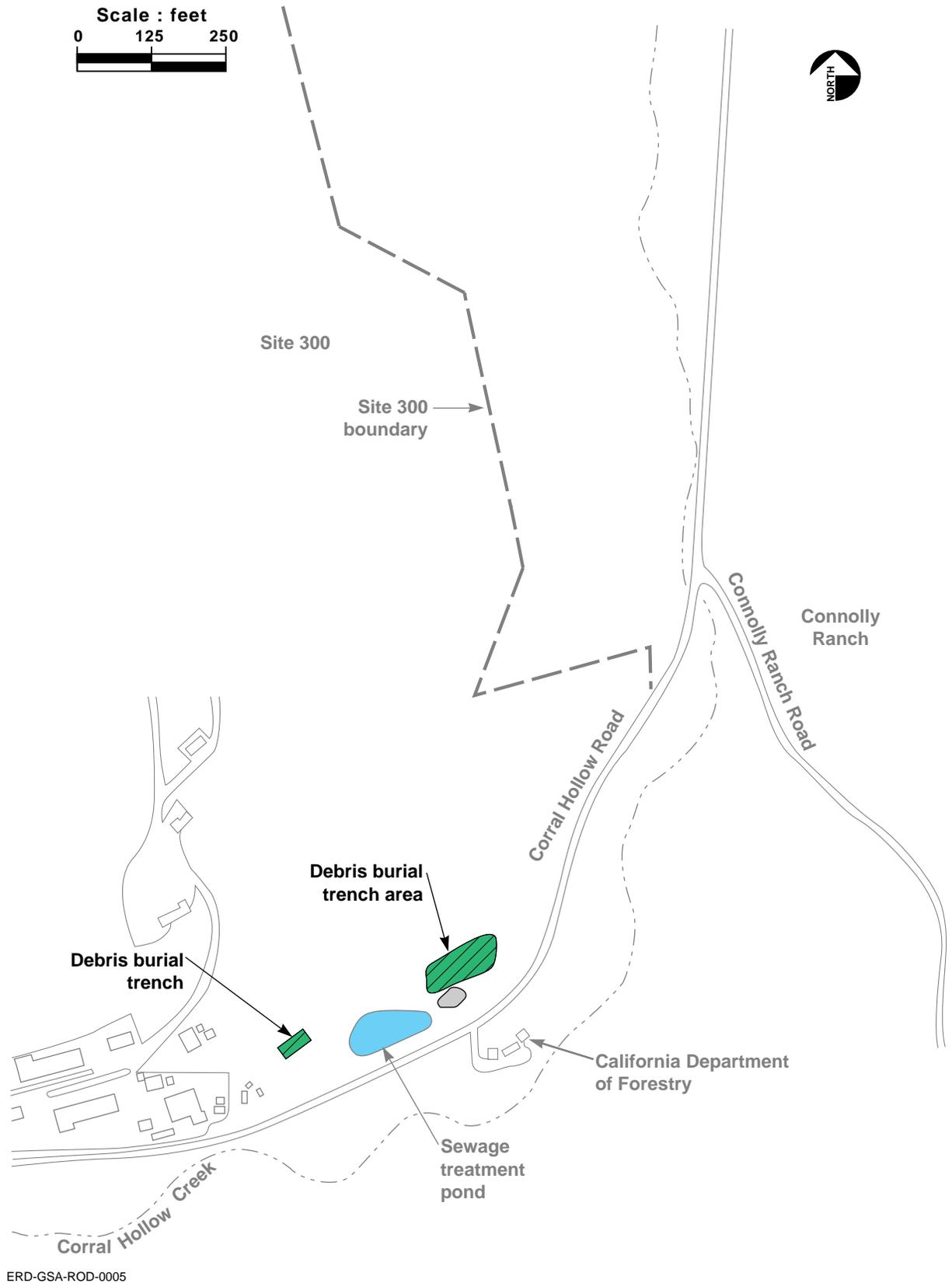


Figure 3. Conceptual hydrogeologic model of the General Services Area.



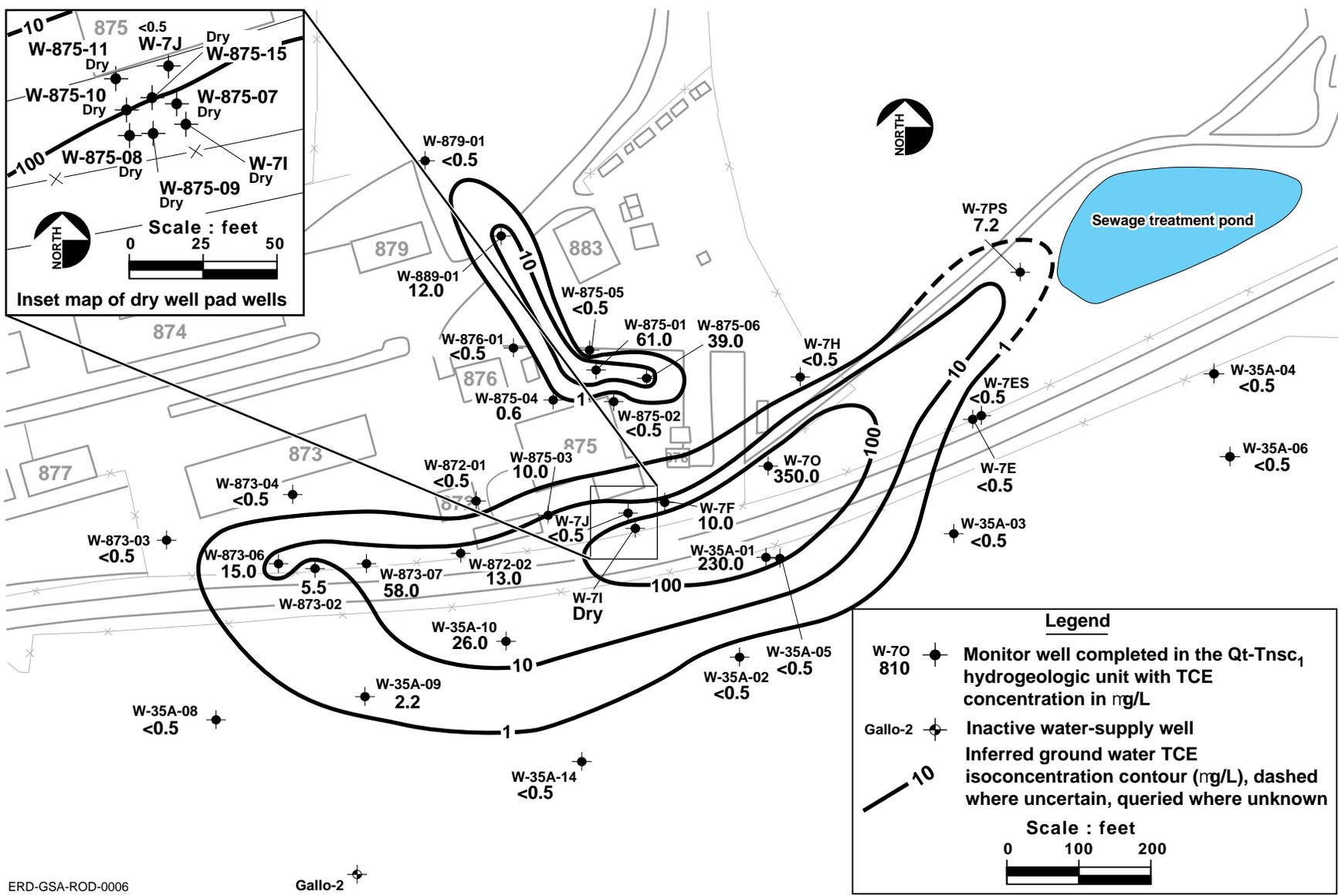
ERD-GSA-ROD-0004

Figure 4. Confirmed chemical release sites in the central GSA.



ERD-GSA-ROD-0005

Figure 5. Confirmed chemical release sites in the eastern GSA.



ERD-GSA-ROD-0006

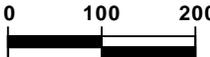
Gallo-2

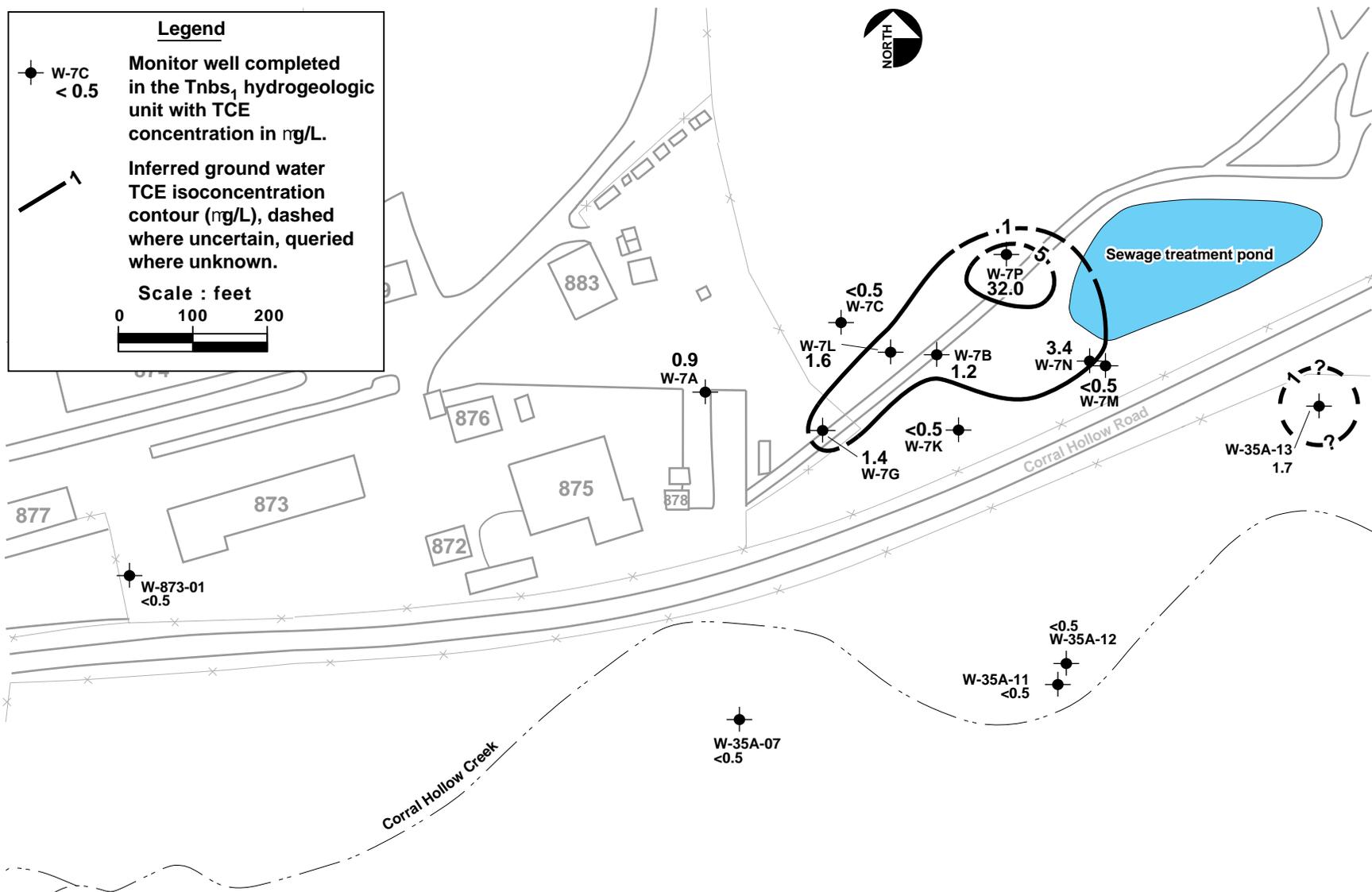
Figure 6. TCE concentrations in ground water from the shallow aquifer (Qt-Tnsc₁) in the central GSA (4th quarter 1995 data).

Legend

 W-7C
 < 0.5
 Monitor well completed in the Tnbs₁ hydrogeologic unit with TCE concentration in ng/L.

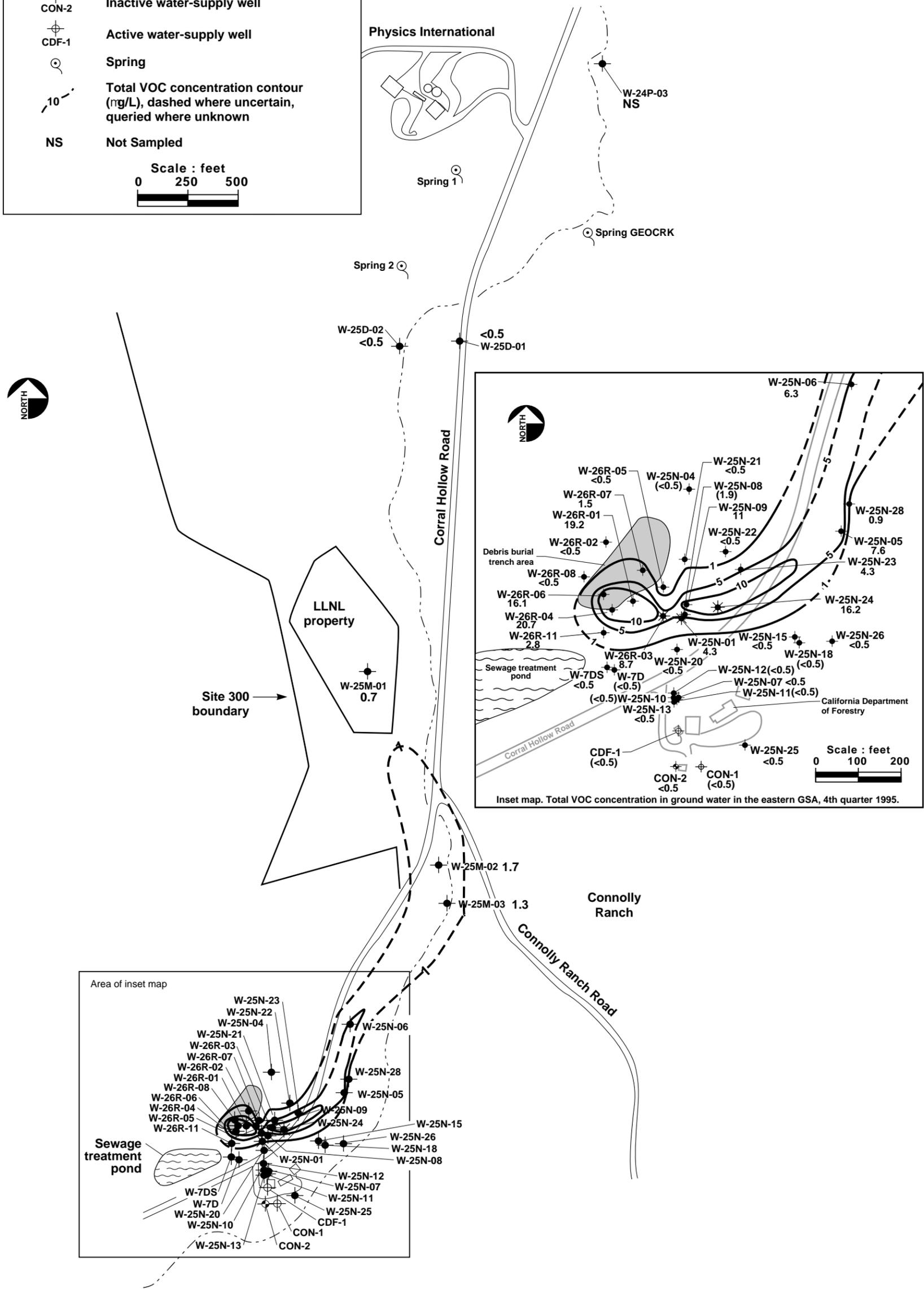
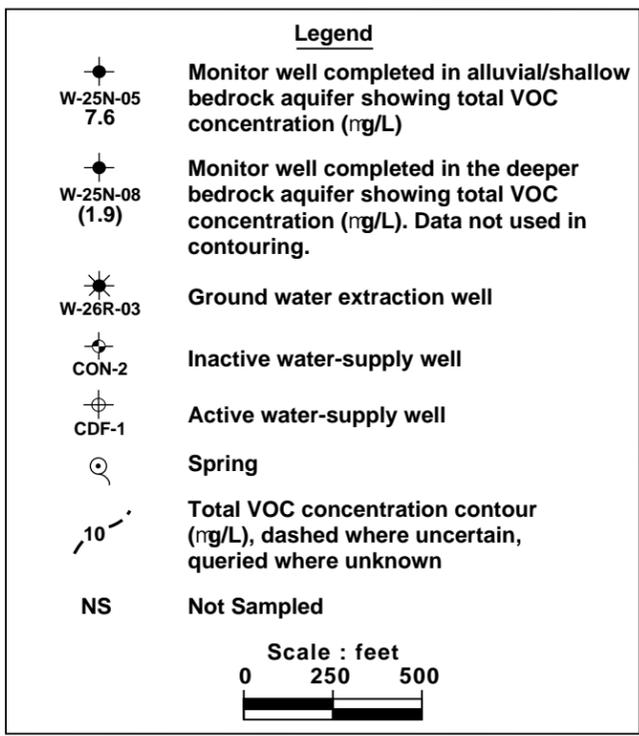

 Inferred ground water TCE isoconcentration contour (ng/L), dashed where uncertain, queried where unknown.

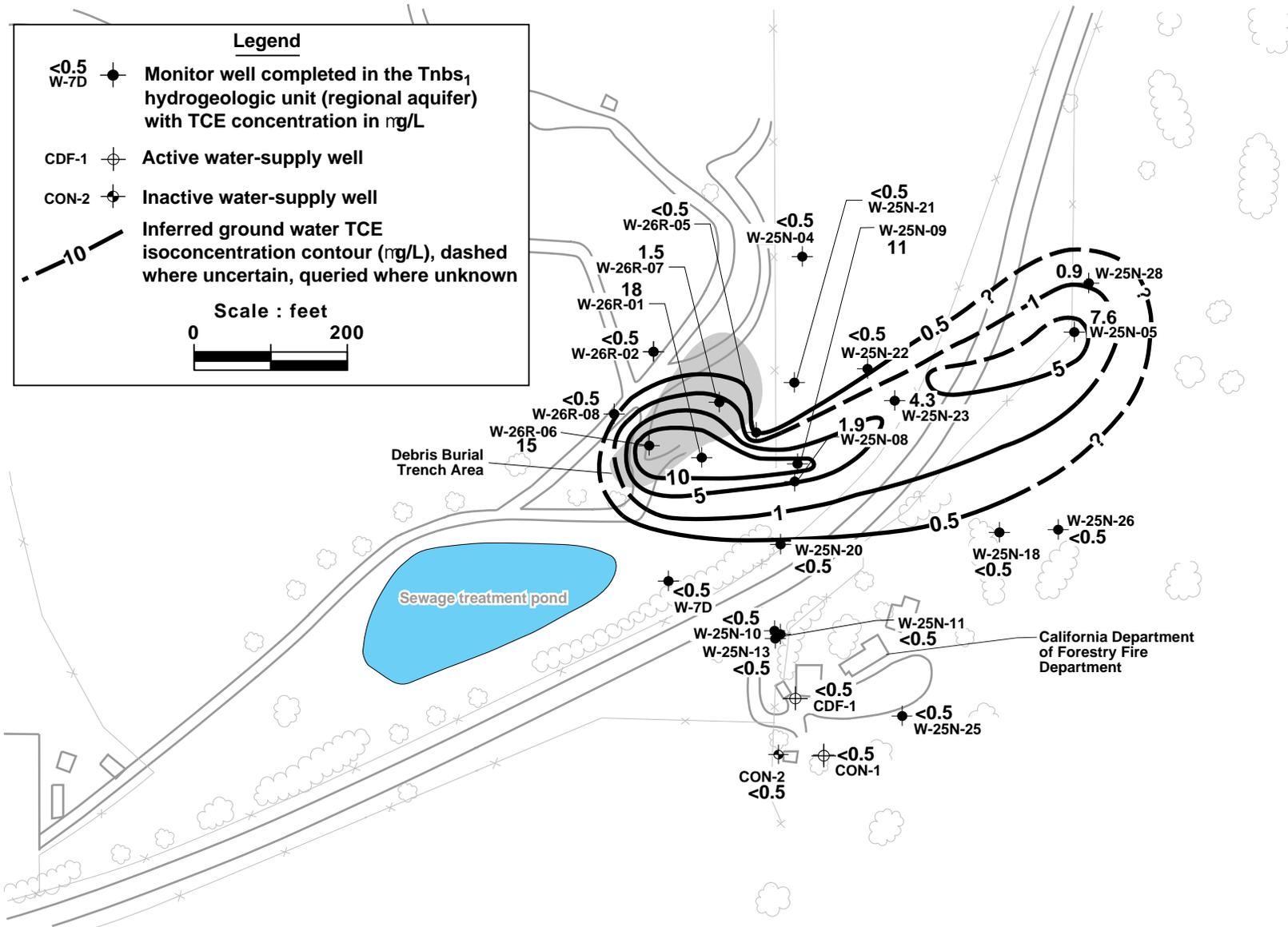
Scale : feet

 0 100 200



ERD-GSA-ROD-0014

Figure 7. TCE concentrations in ground water from the Tnbs₁ regional aquifer in the central GSA (4th quarter 1995 data).





ERD-GSA-ROD-0009

Figure 9. TCE concentrations in ground water from the deeper Tnbs₁ regional aquifer in the eastern GSA (4th quarter 1995 data).

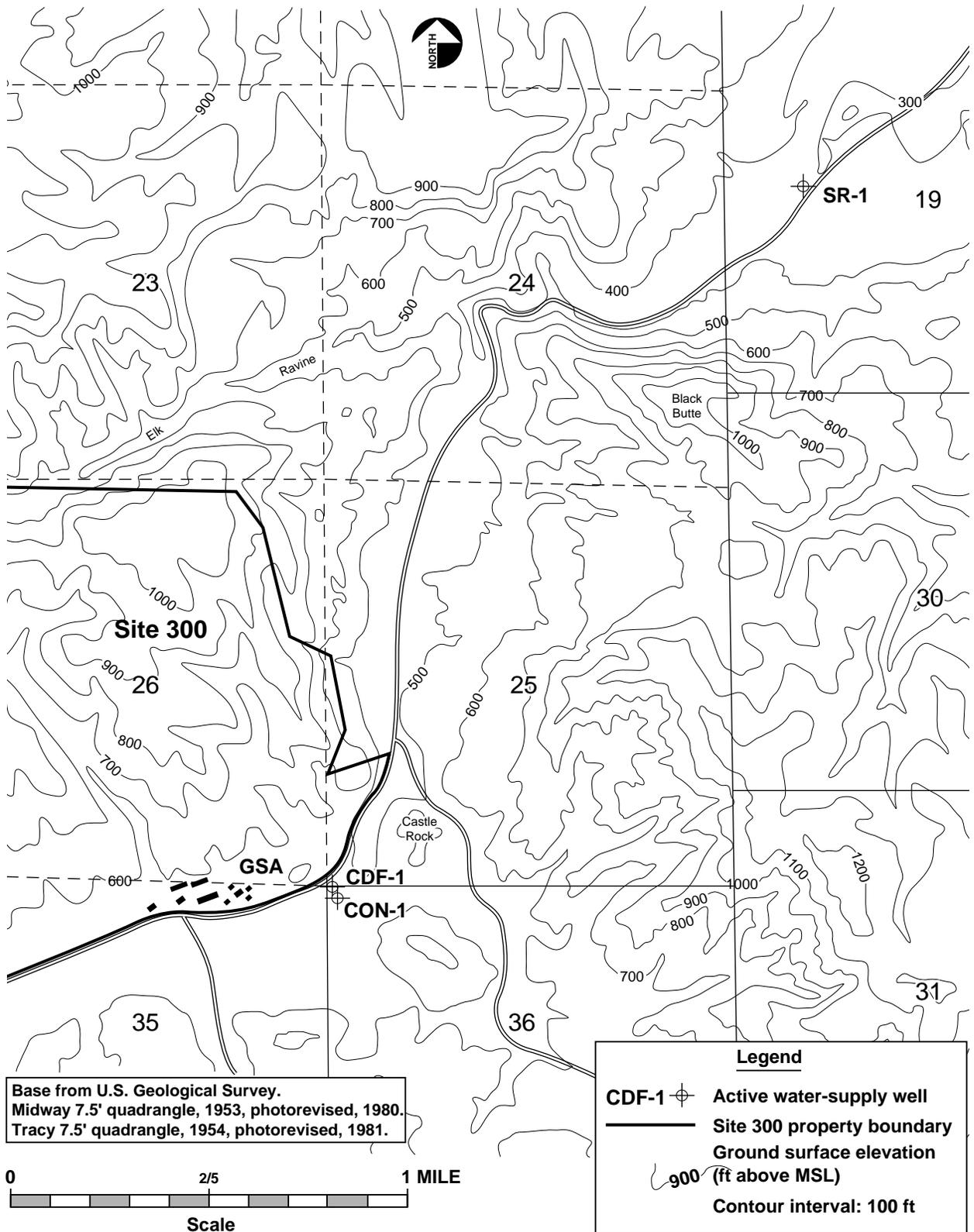


Figure 10. Locations of active water-supply wells.

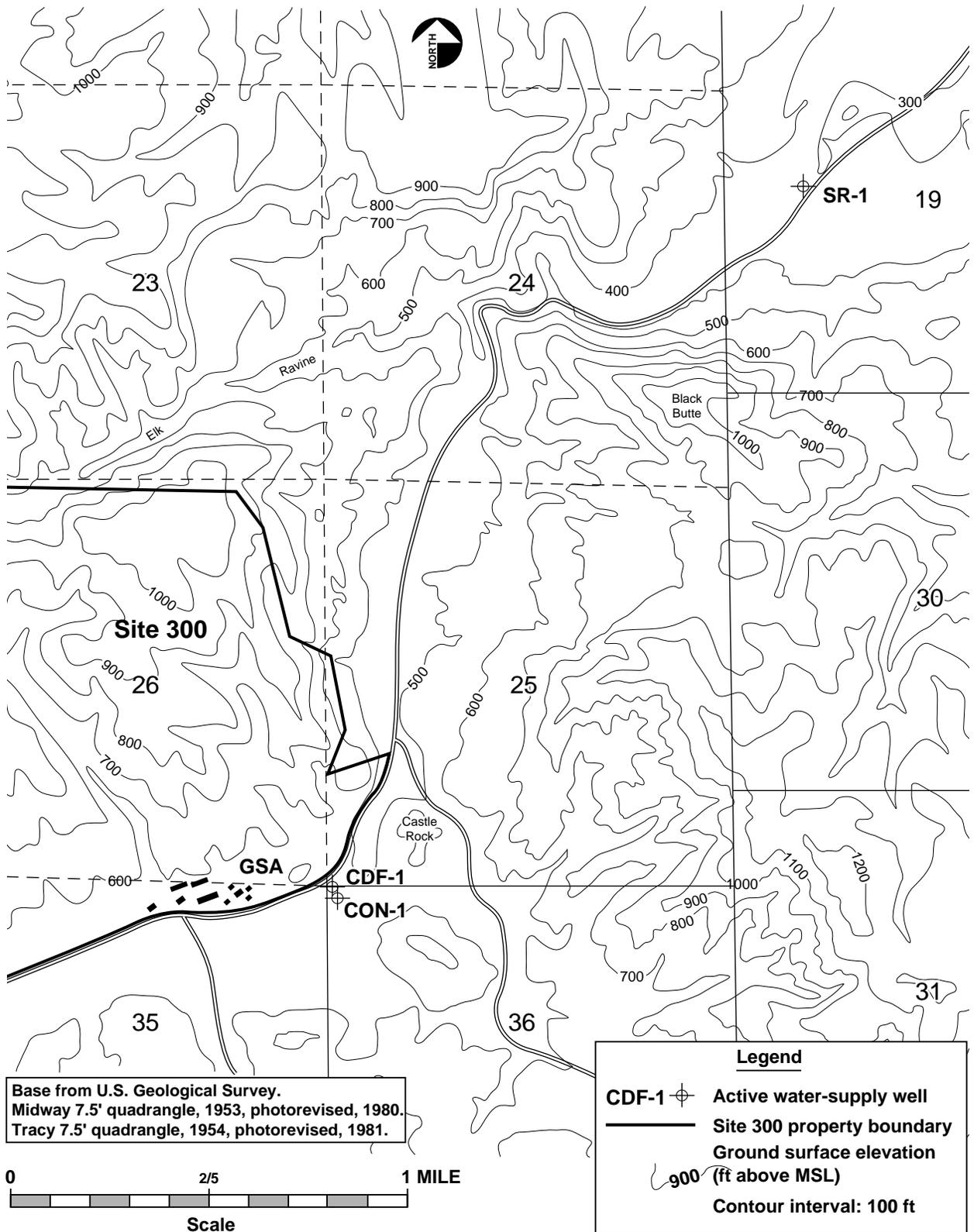


Figure 10. Locations of active water-supply wells.

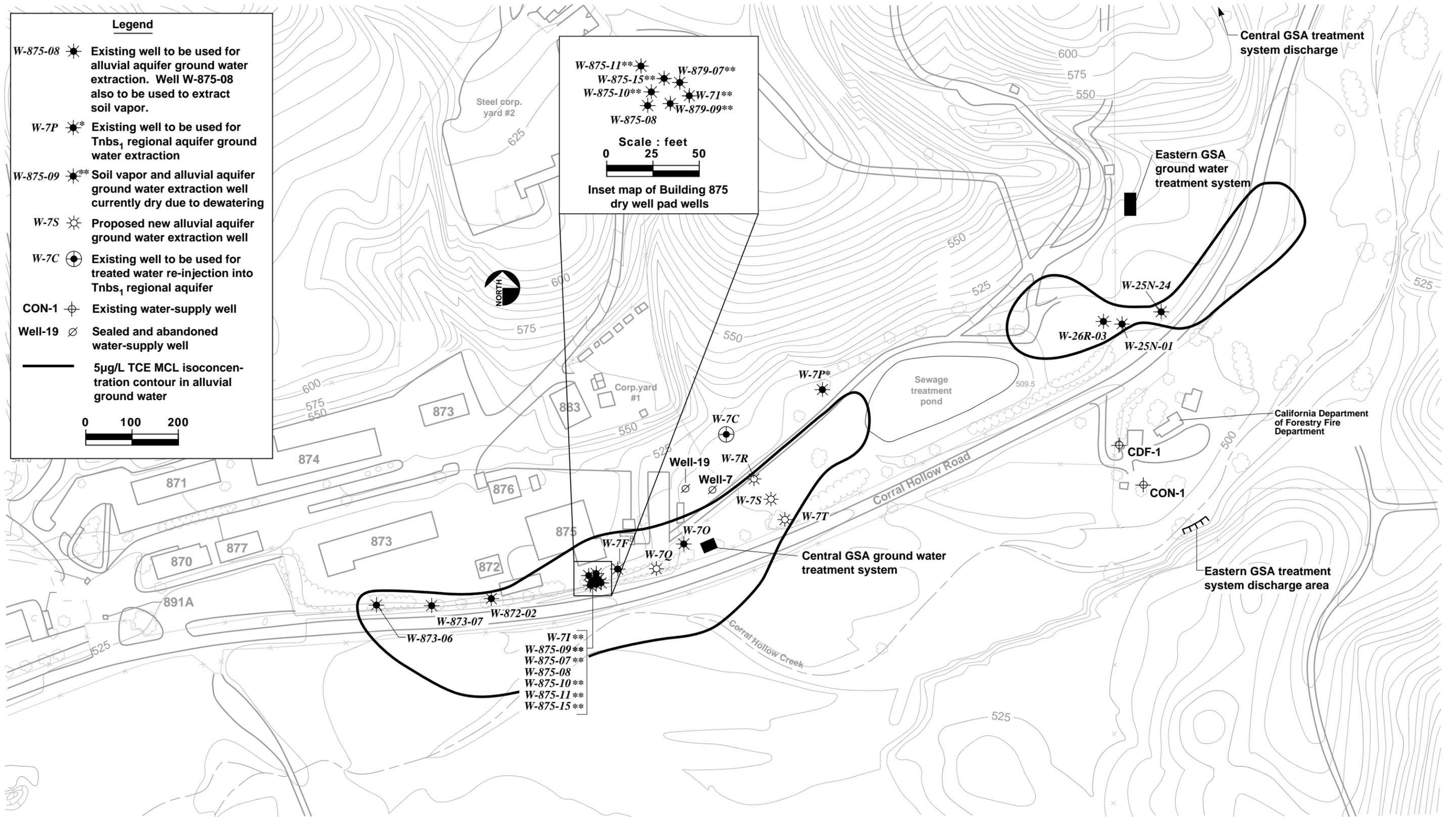


Figure 11. Locations of existing and proposed ground water extraction and reinjection wells, soil vapor extraction wells, and treatment systems.

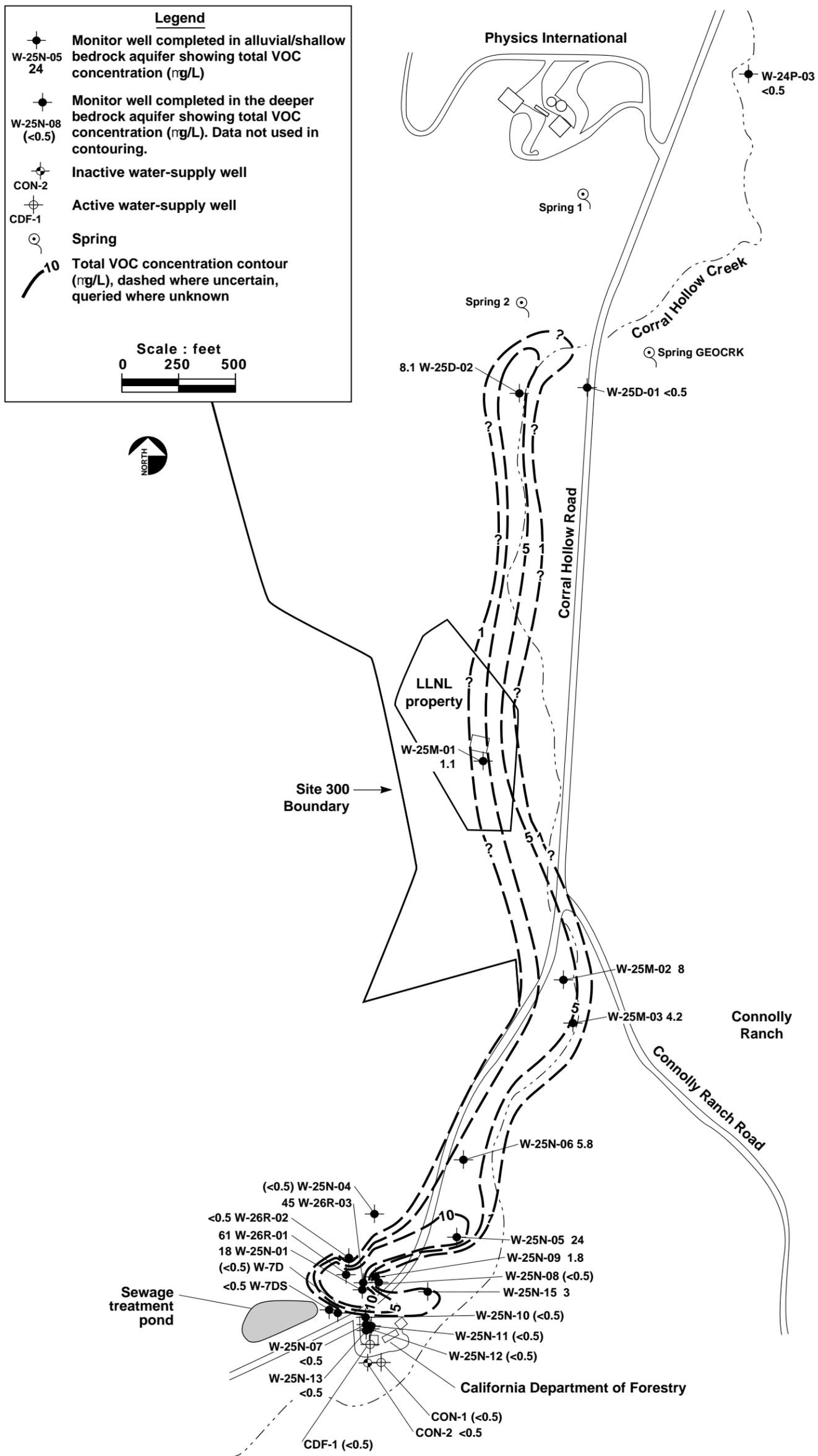
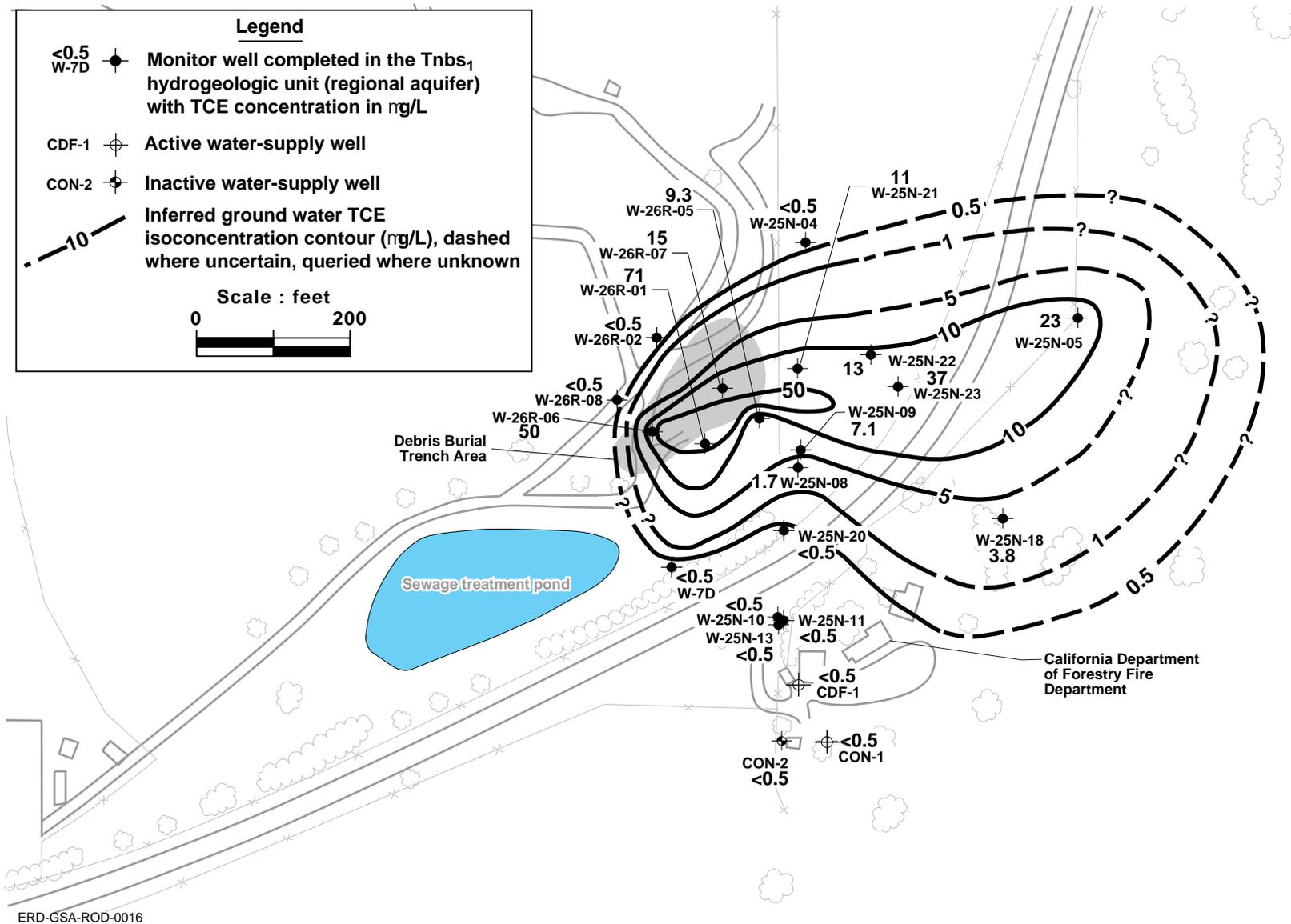
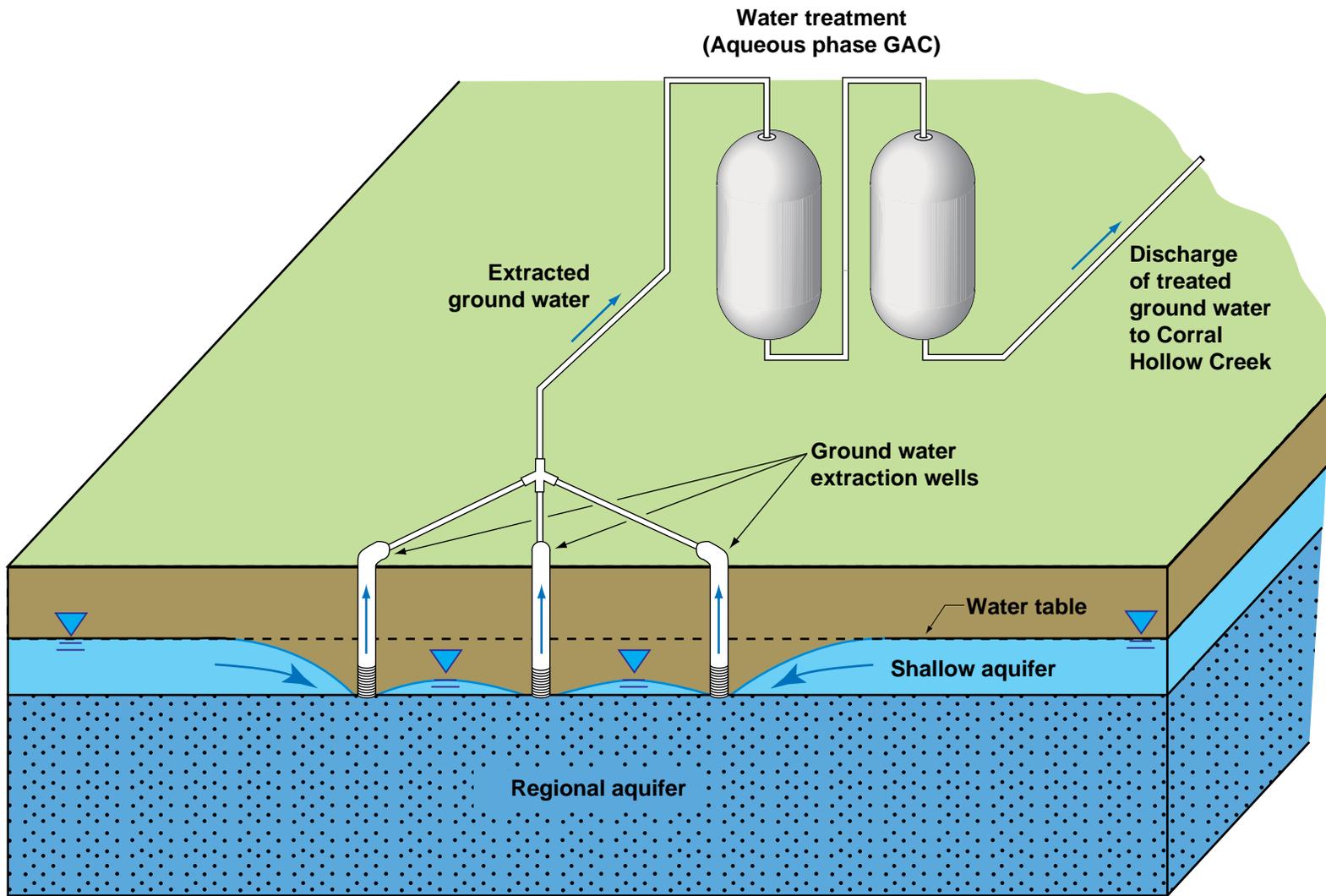


Figure 12. Total VOC concentrations in ground water in the alluvium (Qal) and shallow bedrock (Tnbs₁) in the eastern GSA (4th quarter 1991 data).



ERD-GSA-ROD-0016

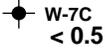
Figure 13. TCE concentrations in ground water from the deeper Tnbs₁ regional aquifer in the eastern GSA (3rd quarter 1992 data).



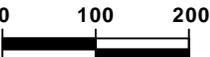
ERD-GSA-ROD-0012

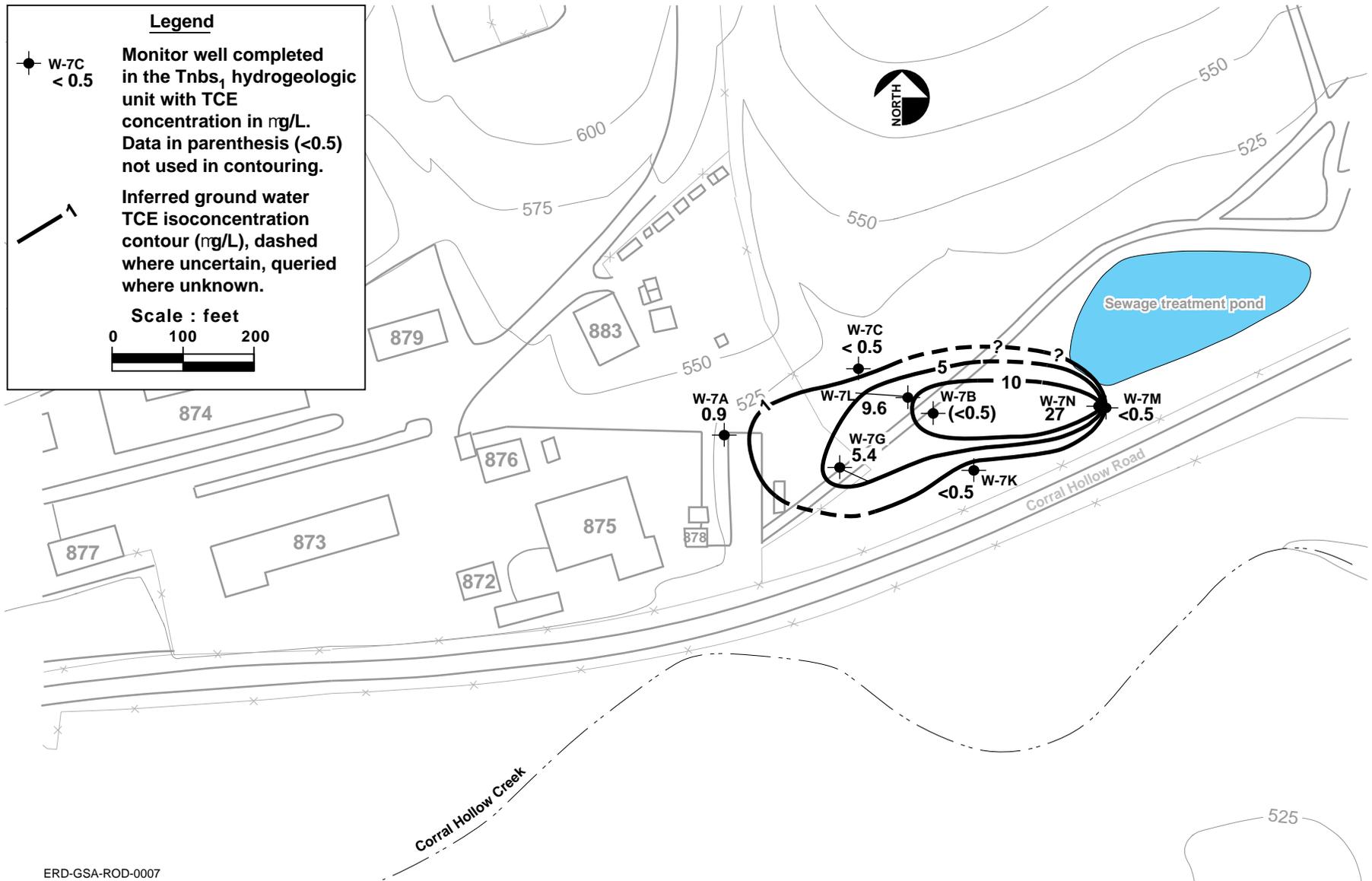
Figure 14. Schematic of the eastern GSA remediation system for the selected remedy (Alternative 3b).

Legend


Monitor well completed in the Tnbs₁ hydrogeologic unit with TCE concentration in mg/L. Data in parenthesis (<0.5) not used in contouring.

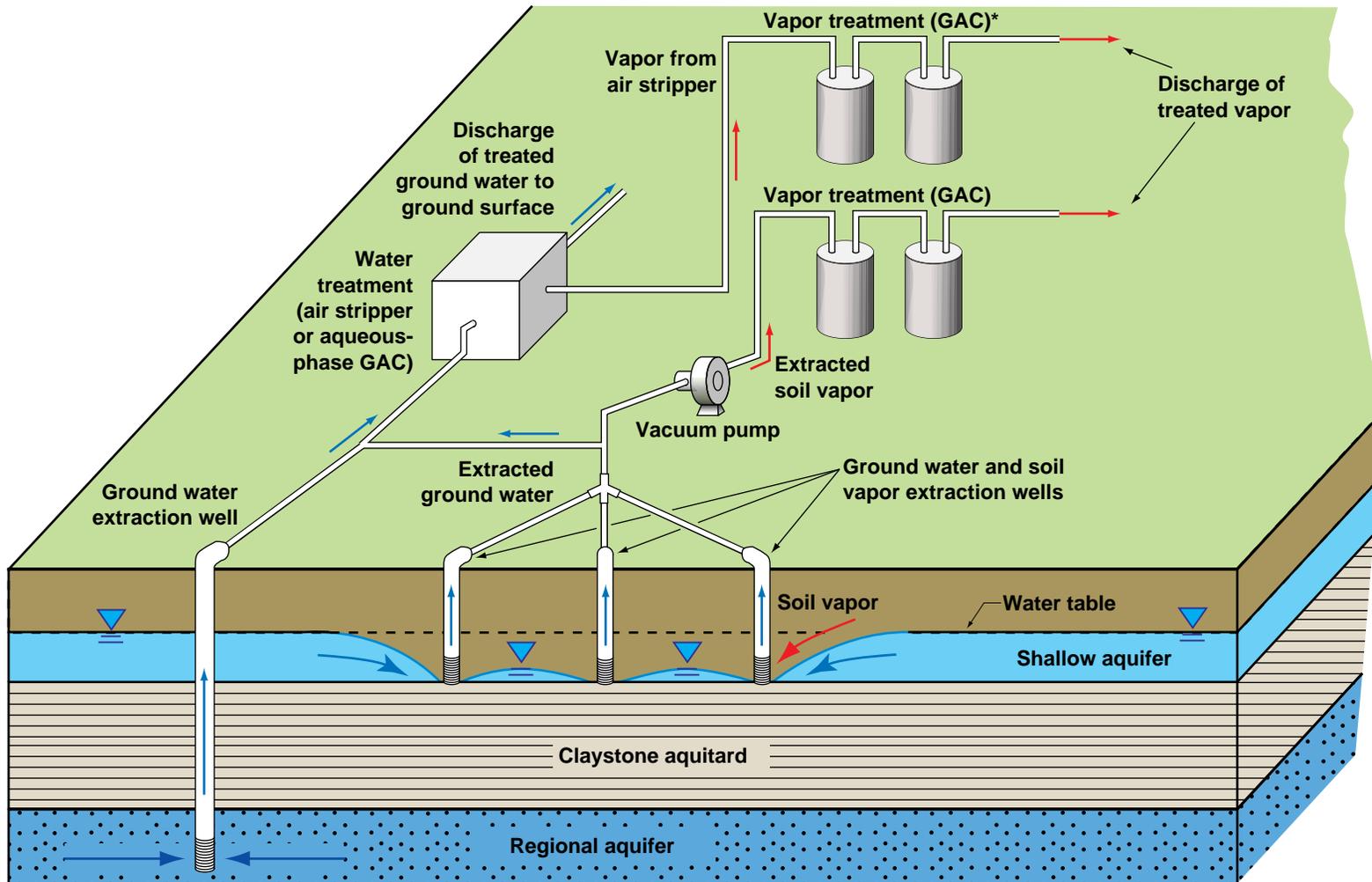

Inferred ground water TCE isoconcentration contour (mg/L), dashed where uncertain, queried where unknown.

Scale : feet




ERD-GSA-ROD-0007

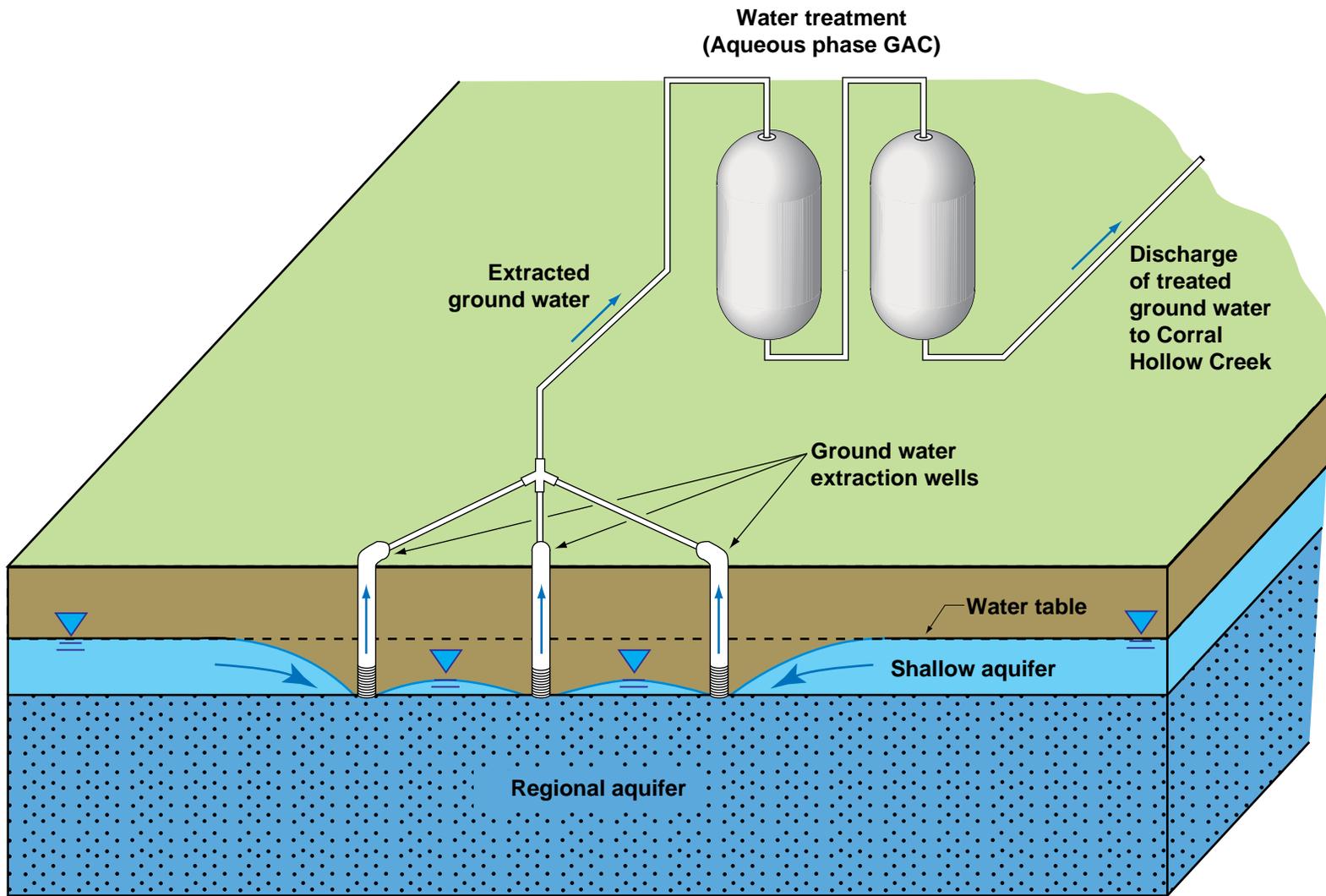
Figure 16. TCE concentrations in ground water from the Tnbs₁ regional aquifer in the central GSA (4th quarter 1991 data).



* Treatment of vapor from ground water treatment system is not necessary if aqueous-phase GAC is used.

ERD-GSA-ROD-0013

Figure 17. Schematic of the central GSA remediation system for the selected remedy (Alternative 3b).



ERD-GSA-ROD-0012

Figure 14. Schematic of the eastern GSA remediation system for the selected remedy (Alternative 3b).

Tables

Table 1. Contaminants of potential concern in ground water in the GSA.

Contaminant	Maximum concentration ^a	Mean concentration ^{a,b}	95% UCL ^a
Central GSA			
1,1,1-trichloroethane	2.0×10^3	2.93×10^{-1}	1.62×10^0
1,1-dichloroethylene	4.0×10^3	7.37×10^{-1}	1.18×10^0
cis-1,2-dichloroethylene ^c	1.0×10^3	2.56×10^0	3.75×10^0
Acetone	8.2×10^0	4.08×10^0	5.78×10^0
Benzene	5.0×10^{1d}		
Bromodichloromethane	3.3×10^0	4.05×10^{-2}	6.62×10^{-2}
Chloroform	7.4×10^0	6.10×10^{-1}	8.98×10^{-1}
Tetrachloroethylene	2.5×10^4	3.89×10^1	7.73×10^1
Trichloroethylene	2.4×10^5	8.30×10^2	3.09×10^3
Trichlorofluoromethane (Freon 113)	1.6×10^2	1.07×10^1	1.89×10^1
Eastern GSA			
1,1,1-trichloroethane	9.4×10^1	2.93×10^{-1}	1.62×10^0
1,1-dichloroethylene	5.0×10^{-1}	4.30×10^{-1}	4.45×10^{-1}
1,2-dichloroethylene ^c	6.0×10^{-1}	4.27×10^{-1}	4.41×10^{-1}
Bromodichloromethane	3.3×10^0	4.05×10^{-2}	6.62×10^{-2}
Chloroform	1.4×10^1	9.60×10^{-1}	4.25×10^0
Tetrachloroethylene	4.4×10^0	1.32×10^0	1.64×10^0
Trichloroethylene	6.1×10^1	2.66×10^1	3.39×10^1

^a All units are in $\mu\text{g/L}$.

^b Estimate of the arithmetic mean of the underlying log normal distribution.

^c The chemical 1,2-dichloroethylene (1,2-DCE) exists as two isomers, cis-1,2-DCE and trans-1,2-DCE. At various times throughout the nine years of ground water analysis at Site 300, this chemical has been analyzed for as 1,2-DCE (total), as one or both of the specific isomers, or as all three. When concentration data were available for one or both isomers, we used those values and omitted the less specific analysis for total 1,2-DCE from further consideration. The exceptions to this were in cases where the concentration reported for total 1,2-DCE was greater than that reported for one or both isomers.

^d The value given for benzene is the maximum measured concentration for this chemical in ground water in the central GSA. This maxima was reported from the last quarter of sampling data included in the SWRI database (first quarter, 1992) (Webster-Scholton, 1994), and came from the vicinity of the Building 875 former dry wells. A mean concentration and a 95% Upper Confidence Limit (UCL) were not calculated.

Table 2. Contaminants of potential concern in surface soil (0.5 ft) in the GSA.

Contaminant	Maximum concentration ^a	Mean concentration ^{a,b}	95% UCL ^a
1,1,1-trichloroethane	5.0×10^{-3}	6.85×10^{-4}	1.86×10^{-3}
Acetone	6.0×10^{-2}	3.39×10^{-2}	4.90×10^{-2}
Cadmium	1.6×10^1	6.43×10^0	9.31×10^0
Chloroform	3.0×10^{-4}	3.82×10^{-4}	8.75×10^{-4}
Copper	3.4×10^2	3.94×10^1	5.67×10^1
HMX	2.0×10^{-2}	NA ^c	2.0×10^{-2c}
Tetrachloroethylene	3.0×10^{-2}	1.61×10^{-3}	3.58×10^{-3}
Toluene	6.0×10^{-3}	1.30×10^{-3}	2.86×10^{-3}
Trichloroethylene	8.4×10^{-2}	3.75×10^{-3}	1.18×10^{-2}
Trichlorofluoromethane (Freon 113)	1.3×10^{-2}	1.00×10^{-3}	2.19×10^{-3}
Trichlorotrifluoroethane (Freon 11)	7.9×10^{-2}	1.23×10^{-2}	3.84×10^{-2}
Xylenes (total isomers)	7.0×10^{-3}	1.47×10^{-3}	3.40×10^{-3}
Zinc	8.3×10^2	2.06×10^2	3.62×10^2

^a Units are mg/kg.

^b Estimate of the arithmetic mean of the underlying log normal distribution.

^c For certain data sets, calculation of an UCL yielded a value greater than the maximum measured concentration. In those instances, a mean concentration was not calculated, and the maximum concentration is given instead of a UCL.

Table 3. Contaminants of potential concern in subsurface soil (>0.5–12.0 ft) in the GSA.

Operable unit region	Contaminant	Maximum concentration ^a	Mean concentration ^{a,b}	95% UCL ^a
Building 875	1,1,1-trichloroethane	1.0×10^{-2}	2.13×10^{-3}	4.38×10^{-3}
	1,1-dichloroethylene	5.0×10^{-4}	NC ^c	5.0×10^{-4c}
	cis-1,2-dichloroethylene	3.0×10^{-4}	1.88×10^{-4}	2.96×10^{-4}
	Chloroform	3.0×10^{-4}	1.88×10^{-4}	2.96×10^{-4}
	Tetrachloroethylene	1.0×10^{-1}	3.28×10^{-2}	7.54×10^{-2}
	Trichloroethylene	5.4×10^{-1}	1.74×10^{-1}	4.14×10^{-1}
	Trichlorotrifluoroethane (Freon 11)	6.0×10^{-2}	8.03×10^{-3}	1.87×10^{-2}
Debris burial trenches	Chloroform	4.3×10^{-2}	1.47×10^{-3}	3.35×10^{-3}
	Methylene chloride	1.4×10^{-2}	4.26×10^{-4}	1.74×10^{-3}
	Tetrachloroethylene	8.8×10^{-3}	1.95×10^{-3}	4.32×10^{-3}
	Toluene	5.0×10^{-3}	2.73×10^{-3}	3.14×10^{-3}
	Trichloroethylene	2.4×10^{-2}	2.43×10^{-3}	4.31×10^{-3}
	Trichlorofluoromethane (Freon 113)	3.3×10^{-3}	1.34×10^{-4}	3.95×10^{-4}
	Trichlorotrifluoroethane (Freon 11)	4.0×10^{-4}	1.20×10^{-4}	1.67×10^{-4}

^a Units are mg/kg.

^b Estimate of the arithmetic mean of the underlying log normal distribution.

^c NC = Not calculated. For certain data sets, calculation of a UCL yielded a value greater than the maximum measured concentration (Webster-Scholten, 1994, Appendix P). In those instances, a mean concentration was not calculated, and the maximum concentration is given instead of a UCL.

Table 4. Contaminants of potential concern in VOC soil flux in the GSA.

Contaminant	Limit of detection (mg/m ² •s)	Maximum emission rate (mg/m ² •s)	Mean emission rate ^a (mg/m ² •s)	95% UCL of emission rate (mg/m ² •s)
Central GSA				
1,2,4-trimethylbenzene	1.05 × 10 ⁻⁶	9.19 × 10 ⁻⁶	1.25 × 10 ⁻⁶	2.00 × 10 ⁻⁶
1,3,5-trimethylbenzene	1.10 × 10 ⁻⁶	2.00 × 10 ⁻⁶	NA ^b	2.10 × 10 ⁻⁶
Benzene	6.79 × 10 ⁻⁷	2.39 × 10 ⁻⁵	1.73 × 10 ⁻⁶	3.64 × 10 ⁻⁶
Methylene chloride	9.50 × 10 ⁻⁷	5.20 × 10 ⁻⁵	4.36 × 10 ⁻⁶	1.69 × 10 ⁻⁵
Toluene	8.01 × 10 ⁻⁷	3.59 × 10 ⁻⁶	1.03 × 10 ⁻⁶	1.37 × 10 ⁻⁶
Trichloroethylene	1.13 × 10 ⁻⁶	3.73 × 10 ⁻⁶	3.33 × 10 ⁻⁷	1.11 × 10 ⁻⁶
Trichlorotrifluoroethane (Freon 113)	1.70 × 10 ⁻⁶	3.88 × 10 ⁻⁴	7.49 × 10 ⁻⁵	2.22 × 10 ⁻⁴
m- and p-xylenes	9.58 × 10 ⁻⁷	5.27 × 10 ⁻⁶	1.11 × 10 ⁻⁶	1.97 × 10 ⁻⁶
o-xylenes	9.58 × 10 ⁻⁷	2.43 × 10 ⁻⁶	5.15 × 10 ⁻⁷	9.35 × 10 ⁻⁷
Eastern GSA				
1,1,1-trichloroethane	1.18 × 10 ⁻⁶	1.32 × 10 ⁻⁶	1.11 × 10 ⁻⁶	1.32 × 10 ⁻³
1,2,4-trichlorobenzene	1.09 × 10 ⁻⁶	2.11 × 10 ⁻⁶	1.11 × 10 ⁻⁶	1.36 × 10 ⁻⁶
Dichlorodifluoromethane (Freon 12)	1.09 × 10 ⁻⁶	2.45 × 10 ⁻⁶	6.48 × 10 ⁻⁷	1.12 × 10 ⁻⁶
Methylene chloride	8.67 × 10 ⁻⁷	6.06 × 10 ⁻⁵	7.63 × 10 ⁻⁶	3.52 × 10 ⁻⁵
Styrene	9.07 × 10 ⁻⁷	1.42 × 10 ⁻⁶	4.90 × 10 ⁻⁷	1.01 × 10 ⁻⁶
Toluene	8.34 × 10 ⁻⁷	1.67 × 10 ⁻⁶	1.10 × 10 ⁻⁶	1.27 × 10 ⁻⁶
Trichloroethylene	1.18 × 10 ⁻⁶	1.77 × 10 ⁻⁶	6.89 × 10 ⁻⁷	1.35 × 10 ⁻⁶
Trichlorotrifluoroethane (Freon 113)	1.77 × 10 ⁻⁵	5.67 × 10 ⁻⁵	3.40 × 10 ⁻⁵	4.06 × 10 ⁻⁵
m- and p-xylenes	9.98 × 10 ⁻⁷	2.87 × 10 ⁻⁶	1.32 × 10 ⁻⁶	1.63 × 10 ⁻⁶
o-xylenes	9.98 × 10 ⁻⁷	1.45 × 10 ⁻⁶	6.13 × 10 ⁻⁷	1.16 × 10 ⁻⁶
Building 875 dry well area				
1,2,4-trimethylbenzene	1.09 × 10 ⁻⁶	3.89 × 10 ⁻⁶	1.09 × 10 ⁻⁶	1.98 × 10 ⁻⁶
Chloromethane	4.63 × 10 ⁻⁷	1.12 × 10 ⁻⁶	1.87 × 10 ⁻⁷	4.38 × 10 ⁻⁷
Dichlorodifluoromethane (Freon 12)	1.09 × 10 ⁻⁶	1.10 × 10 ⁻⁶	NA ^b	1.10 × 10 ⁻⁶
Ethylbenzene	9.98 × 10 ⁻⁷	4.49 × 10 ⁻⁶	8.77 × 10 ⁻⁷	1.41 × 10 ⁻⁶
Methylene chloride	7.71 × 10 ⁻⁷	2.02 × 10 ⁻⁵	6.37 × 10 ⁻⁶	1.14 × 10 ⁻⁵
Tetrachloroethylene	1.54 × 10 ⁻⁶	2.20 × 10 ⁻⁶	1.02 × 10 ⁻⁶	1.83 × 10 ⁻⁶
Toluene	8.34 × 10 ⁻⁷	1.05 × 10 ⁻⁵	1.55 × 10 ⁻⁶	2.97 × 10 ⁻⁶
Trichloroethylene	1.18 × 10 ⁻⁶	1.68 × 10 ⁻⁵	3.01 × 10 ⁻⁶	1.13 × 10 ⁻⁵

Table 4. (Continued)

Contaminant	Limit of detection (mg/m ² •s)	Maximum emission rate (mg/m ² •s)	Mean emission rate ^a (mg/m ² •s)	95% UCL of emission rate (mg/m ² •s)
Building 875 dry well area (Continued)				
Trichlorotrifluoroethane (Freon 113)	1.82×10^{-6}	8.06×10^{-5}	2.86×10^{-5}	3.96×10^{-5}
m- and p-xylenes	9.98×10^{-7}	1.83×10^{-5}	2.98×10^{-6}	1.30×10^{-5}
o-xylenes	9.98×10^{-7}	3.37×10^{-6}	7.03×10^{-7}	1.39×10^{-6}

^a Estimate of the arithmetic mean of the underlying log normal distribution.

^b For certain data sets, calculation of an UCL yielded a value greater than the maximum measured concentration. In those instances, a mean concentration was not calculated, and the maximum concentration is given instead of a UCL.

Table 5. Summary of fate and transport models applied to estimate human exposure-point concentrations in the GSA OU.

Media/process release area(s)	Model and/or method	Potential exposure point(s)	Chemicals of concern	Maximum concentration at release area(s)	95% Upper Confidence Limit	Estimated exposure-point concentrations
<i>Fugitive (airborne) dust; contaminants bound to resuspended soil particles</i>						
Data evaluated are from surface soil samples collected throughout the OU.	Mass-loading (Anspaugh et al., 1975).	Throughout the OU.	1,1,1-trichloroethane	0.005 mg/kg ^a	0.00186 mg/kg ^a	4.28 × 10 ⁻¹¹ mg/m ^{3b}
			Acetone	0.06 mg/kg ^a	0.049 mg/kg ^a	1.13 × 10 ⁻⁹ mg/m ^{3b}
			Cadmium	16 mg/kg ^a	9.31 mg/kg ^a	2.14 × 10 ⁻⁷ mg/m ^{3b}
			Chloroform	0.0003 mg/kg ^a	0.000875 mg/kg ^a	2.01 × 10 ⁻¹¹ mg/m ^{3b}
			Copper	340 mg/kg ^a	56.7 mg/kg ^a	1.30 × 10 ⁻⁶ mg/m ^{3b}
			HMX	0.02 mg/kg ^a	0.02 mg/kg ^a	4.60 × 10 ⁻¹⁰ mg/m ^{3b}
			Tetrachloroethylene	0.03 mg/kg ^a	0.00358 mg/kg ^a	8.24 × 10 ⁻¹¹ mg/m ^{3b}
			Toluene	0.006 mg/kg ^a	0.00286 mg/kg ^a	6.58 × 10 ⁻¹¹ mg/m ^{3b}
			Trichloroethylene	0.084 mg/kg ^a	0.0118 mg/kg ^a	2.72 × 10 ⁻¹⁰ mg/m ^{3b}
			Trichlorofluoromethane (Freon 11)	0.013 mg/kg ^a	0.00219 mg/kg ^a	5.04 × 10 ⁻¹¹ mg/m ^{3b}
			Trichlorotrifluoroethane (Freon 113)	0.079 mg/kg ^a	0.0384 mg/kg ^a	8.83 × 10 ⁻¹⁰ mg/m ^{3b}
			Total xylenes	0.007 mg/kg ^a	0.0034 mg/kg ^a	7.82 × 10 ⁻¹¹ mg/m ^{3b}
			Zinc	830 mg/kg ^a	362 mg/kg ^a	8.33 × 10 ⁻⁶ mg/m ^{3b}
<i>Surface soil (≤0.5 ft)</i>						
Data evaluated are from surface soil samples collected throughout the OU.	Measured concentration of contaminant in surface soil.	Throughout the OU. (Exposure routes: incidental ingestion and dermal contact.)	1,1,1-trichloroethane	0.005 mg/kg ^a	0.00186 mg/kg ^a	1.86 × 10 ⁻³ mg/kg ^a
			Acetone	0.06 mg/kg ^a	0.049 mg/kg ^a	4.9 × 10 ⁻² mg/kg ^a
			Cadmium	0.16 mg/kg ^a	9.31 mg/kg ^a	9.31 × 10 ⁰ mg/kg ^a
			Chloroform	0.0003 mg/kg ^a	0.000875 mg/kg ^a	8.75 × 10 ⁻⁴ mg/kg ^a
			Copper	340 mg/kg ^a	56.7 mg/kg ^a	5.67 × 10 ¹ mg/kg ^a
			HMX	0.02 mg/kg ^a	0.02 mg/kg ^a	2.00 × 10 ⁻² mg/kg ^a
			Tetrachloroethylene	0.03 mg/kg ^a	0.00358 mg/kg ^a	3.58 × 10 ⁻³ mg/kg ^a
			Toluene	0.006 mg/kg ^a	0.00286 mg/kg ^a	2.86 × 10 ⁻³ mg/kg ^a
			Trichloroethylene	0.084 mg/kg ^a	0.0118 mg/kg ^a	1.18 × 10 ⁻² mg/kg ^a
			Trichlorofluoromethane (Freon 11)	0.013 mg/kg ^a	0.00219 mg/kg ^a	2.19 × 10 ⁻³ mg/kg ^a
			Trichlorotrifluoroethane (Freon 113)	0.079 mg/kg ^a	0.0384 mg/kg ^a	3.84 × 10 ⁻² mg/kg ^a
			Total xylenes	0.007 mg/kg ^a	0.0034 mg/kg ^a	3.40 × 10 ⁻³ mg/kg ^a
			Zinc	830 mg/kg ^a	362 mg/kg ^a	3.62 × 10 ⁻² mg/kg ^a

Table 5. (Continued)

Media/process release area(s)	Model and/or method	Potential exposure point(s)	Chemicals of concern	Maximum concentration at release area(s)	95% Upper Confidence Limit	Estimated exposure-point concentrations
<i>Volatilization of contaminants from subsurface soil into air within a building</i>						
Immediate vicinity of Building 875.	Volatilization of contaminants from subsurface soil and diffusion of VOCs through concrete into a building. VOCs (McKone 1992).	Inside Building 875	1,1-dichloroethylene	0.0005 mg/kg ^c	0.000112 mg/kg ^c	2.39 × 10 ⁻⁶ mg/m ^{3b}
			1,1,1-trichloroethane	0.01 mg/kg ^c	0.00286 mg/kg ^c	1.23 × 10 ⁻⁶ mg/m ^{3b}
			Benzene	0.003 mg/kg ^c	0.000917 mg/kg ^c	1.69 × 10 ⁻⁵ mg/m ^{3b}
			Chloroform	0.0032 mg/kg ^c	0.00199 mg/kg ^c	5.71 × 10 ⁻⁵ mg/m ^{3b}
			cis-1,2-dichloroethylene	0.01 mg/kg ^c	0.00317 mg/kg ^c	3.42 × 10 ⁻⁵ mg/m ^{3b}
			Methylene chloride	0.0013 mg/kg ^c	0.000612 mg/kg ^c	1.55 × 10 ⁻⁵ mg/m ^{3b}
			Tetrachloroethylene	0.1 mg/kg ^c	0.0697 mg/kg ^c	1.10 × 10 ⁻³ mg/m ^{3b}
			Trichloroethylene	0.75 mg/kg ^c	0.596 mg/kg ^c	1.03 × 10 ⁻² mg/m ^{3b}
			Trichlorofluoromethane (Freon 11)	0.0016 mg/kg ^c	0.0016 mg/kg ^c	2.23 × 10 ⁻⁴ mg/m ^{3b}
Trichlorotrifluoroethane (Freon 113)	0.06 mg/kg ^c	0.0209 mg/kg ^c	5.63 × 10 ⁻³ mg/m ^{3b}			
<i>Volatilization of contaminants from subsurface soil to the atmosphere</i>						
Potential releases in the vicinity of the debris burial trench.	Volatilization of contaminants from soil to air (Hwang et al., 1986); air dispersion (Turner, 1982).	In the vicinity of the debris burial trench.	Chloroform	0.043 mg/kg ^c	0.00335 mg/kg ^c	1.35 × 10 ⁻² mg/m ^{3b}
			Methylene chloride	0.014 mg/kg ^c	0.00174 mg/kg ^c	6.23 × 10 ⁻³ mg/m ^{3b}
			Tetrachloroethylene	0.0088 mg/kg ^c	0.00432 mg/kg ^c	1.18 × 10 ⁻² mg/m ^{3b}
			Toluene	0.005 mg/kg ^c	0.00314 mg/kg ^c	6.68 × 10 ⁻³ mg/m ^{3b}
			Trichloroethylene	0.0024 mg/kg ^c	0.000431 mg/kg ^c	1.24 × 10 ⁻² mg/m ^{3b}
			Trichlorofluoromethane (Freon 11)	0.0033 mg/kg ^c	0.000395 mg/kg ^c	7.01 × 10 ⁻³ mg/m ^{3b}
			Trichlorotrifluoroethane (Freon 113)	0.0004 mg/kg ^c	0.000167 mg/kg ^c	5.53 × 10 ⁻³ mg/m ^{3b}
<i>Soil/rock and ground water (Central GSA)</i>						
Building 875 dry well area, solvent drum rack area, Building 879 steam cleaning/sink area, Building 872 dry well, Building 874 dry well, Building 873 dry well, considered as a single release.	Wilson and Miller (1978) mathematical ground water model.	Ground water from the Qt-Tnsc ₁ hydrogeologic unit. Assumes undiluted transport of VOCs from Building 875 area to the Site 300 boundary. Model is used to simulate the transport of TCE through the alluvium to well CDF-1.	Primarily trichloroethylene; co-contaminants detected in ground water samples in the study area also considered.	240,000 µg/L ^{c,d}	35,840 µg/L ^c at site boundary Assumed modeling source term is 1,000 µg/L	35,849 µg/L ^{c,e} 3.83 µg/L ^{c,f}

Table 5. (Continued)

Media/process release area(s)	Model and/or method	Potential exposure point(s)	Chemicals of concern	Maximum concentration at release area(s)	95% Upper Confidence Limit	Estimated exposure-point concentrations
<i>Soil/rock and ground water (Eastern GSA)</i>						
Debris burial trenches.	PLUME analytical ground water model.	Alluvial ground water. Assumes transport of VOCs from release site to the Site 300 boundary and CDF area. Model is used to simulate the transport of TCE through the alluvium to sheep ranch well SR-1.	Primarily trichloroethylene; co-contaminants detected in ground water samples in the study are also considered.	61 µg/L TCE ^{c,d}	Assumed modeling source term is 100 µg/L ^c	33.9 µg/L ^{c,g} 10 µg/E ^f 10 µg/E ^h
<i>Ecological exposure</i>						
Available data throughout the OU considered (Section 1.5.3).	FS, Section 1.5.3 (Rueth and Berry, 1995)	General area of OU and vicinity of debris burial trenches. (Exposure pathways discussed in Section 1.5.3 of the FS)	Primarily TCE, PCE.	FS, Section 1.5.3.	FS, Section 1.5.3.	FS, Section 1.5.3.

^a Surface soil.

^b Air.

^c Ground water.

^d Predicted maximum 70-year average TCE concentration and exposure-point concentration at the Site 300 boundary.

^e Predicted maximum 70-year average TCE concentration and the exposure-point concentration in ground water pumped from CDF-1.

^f Predicted maximum 70-year average TCE concentration and the estimated exposure-point concentration in ground water at the eastern GSA (assuming no plume commingling).

^g Predicted maximum 70-year average TCE concentration and estimated exposure-point concentration at well SR-1.

Notes:

mg/kg = milligram per kilogram.

mg/m³ = milligram per cubic meter.

µg/L = microgram per liter.

Table 6. Cancer risk and hazard index summary, and reference list for the GSA OU.

Potential exposure pathway	Additive incremental excess lifetime cancer risk estimate	Additive hazard index	References for related tables in supporting documents
Inhalation of VOCs that volatilize from soil to outdoor air in the vicinity of the Building 875 dry well area in the central GSA (AOS exposure)	2×10^{-7}	6.2×10^{-3}	FS: Tables 1-28 1-31 1-34
Inhalation of VOCs that volatilize from soil to outdoor air in the vicinity of the central GSA (AOS exposure)	7×10^{-7}	1.2×10^{-3}	FS: Tables 1-29 1-32 1-35
Inhalation of VOCs that volatilize from soil to outdoor air in the vicinity of the eastern GSA (AOS exposure)	2×10^{-7}	1.3×10^{-3}	FS: Tables 1-30 1-33 1-36
Inhalation of VOCs that volatilize from subsurface soil into the indoor air of Building 875 in the central GSA (AOS exposure)	1×10^{-5}	3.0×10^{-1}	SWRI (Chapter 6): Table 6-51 Appendix P Tables P-27-6.1 P-27-6.10
Potential AOS exposure to contaminants in surface soil (0 to 0.5 ft) in the GSA for:			FS: Table 1-25
a) inhalation of particulates resuspended from surface soil, and b) ingestion and dermal adsorption to surface soil	a) 2×10^{-7} b) 2×10^{-10}	a) 5.6×10^{-5} b) 8.5×10^{-3}	SWRI (Appendix P): Tables P-27-6 a) P-27-6.11 b) P-27-6.12

Table 6. (Continued)

Potential exposure pathway	Additive incremental excess lifetime cancer risk estimate	Additive hazard index	Location of related tables in supporting documents
Adult Onsite Exposure in the GSA	9×10^{-7}	9.8×10^{-3}	FS: Table 1-37 SWRI (Chapter 6): Table 6-55
Potential residential exposure to contaminated ground water that originates in the GSA at:			FS: Table 1-26
a) Central GSA site boundary	a) 7×10^{-2}	a) 5.6×10^2	SWRI (Appendix P):
b) Eastern GSA site boundary	b) 5×10^{-5}	b) 5.0×10^{-1}	Tables P-27-6.5
c) Well CDF-1	c) 1×10^{-5}	c) 1.4×10^{-1}	P-27-6.6
d) Well SR-1	d) 2×10^{-5}	d) 1.6×10^{-1}	P-27-6.7
			P-27-6.8
			P-27-6.13
			P-27-6.14
			P-27-6.15
			P-27-6.16

Notes:

AOS = Adult Onsite.

FS = Final Feasibility Study for the General Services Area, LLNL Site 300 (Rueth and Berry, 1995).

GSA = General Services Area.

SWRI = Final Site-Wide Remedial Investigation Report, LLNL Site 300 (Webster-Scholten, 1994).

VOC = Volatile Organic Compound.

Table 7. Summary of GSA OU remedial alternatives.

Alternative 1: No action	<ul style="list-style-type: none"> • Monitoring <ul style="list-style-type: none"> — Quarterly water level measurements of monitor wells and supply wells. — Periodic ground water sampling and analysis of monitor wells and supply wells. — QA/QC samples. • Administrative controls <ul style="list-style-type: none"> — Fencing and warning signs around site. — Full-time security guards on site. • Continued ecological surveys. • Other <ul style="list-style-type: none"> — Well and pump maintenance. — Reporting. — Project management. — Database management. — QA/QC review. <p>Modeled project life: 80 years of ground water monitoring to reach MCLs.</p>
Alternative 2: Exposure control	<p>All elements of Alternative 1 plus:</p> <ul style="list-style-type: none"> • Contingency POU treatment <ul style="list-style-type: none"> — Install and operate POU GAC treatment system for offsite water-supply wells CDF-1, CON-1, and SR-1 if VOC concentrations exceed MCLs. <p>Modeled project life: 80 years of ground water monitoring to reach MCLs.</p>
Alternative 3a: Remediation and protection of the Tnbs₁ regional aquifer	<p>All elements of Alternative 2 plus:</p> <ul style="list-style-type: none"> • Ground water extraction well installation <ul style="list-style-type: none"> — Install four new ground water extraction wells. — Convert six existing monitor wells to ground water extraction wells and one to an injection well. • Ground water extraction and treatment <ul style="list-style-type: none"> — Extract ground water from 20 extraction wells (19 shallow alluvial, 1 Tnbs₁ regional) and reinject into 1 well (Tnbs₁ regional). — Install new ground water treatment systems using air stripping, VOC adsorption, and/or other appropriate technologies. Design capacity would be approximately 15+ gpm at the central GSA and 46+ gpm at the eastern GSA. — Extract ground water from Tnbs₁ regional aquifer until VOC concentrations reach MCLs. — Extract ground water from the alluvial aquifer until ground water VOC concentrations are reduced to levels protective of the Tnbs₁ regional aquifer (approximately 100 µg/L).

Table 7. (Continued)

	<ul style="list-style-type: none"> • Soil vapor extraction (SVE) and treatment <ul style="list-style-type: none"> — SVE from seven existing wells. — SVE and treatment using existing system until vapor concentrations reach levels that prevent recontamination of ground water above MCLs, and to reduce inhalation risk in Building 875. • Other <ul style="list-style-type: none"> — Permitting. — Ground water treatment system and SVE system maintenance. <p>Project life: 10 years of SVE, 10 years of ground water extraction and treatment at the eastern GSA and 30 years at the central GSA, and 70 years of ground water monitoring to reach MCLs.</p>
Alternative 3b: Ground water plume remediation	<p>All elements of Alternative 3a plus:</p> <ul style="list-style-type: none"> • Continued ground water extraction and treatment at the central GSA until ground water VOC concentrations are reduced to MCLs. <p>Project life: 10 years of SVE, 10 years of ground water extraction and treatment at the eastern GSA and 55 years at the central GSA, and 60 years of ground water monitoring to reach MCLs.</p>

Table 8. Comparative evaluation of remedial alternatives for the GSA OU.

Alternative	Overall protection of human health and environment	Compliance with ARARs	Short-term effectiveness	Long-term effectiveness and permanence	Reduction in contaminant volume, toxicity, and mobility	Implementability	Cost ^{a,b}
Alternative 1 No action	Human health: No Environment: No	Criterion may be met ^c	Protective of site workers and the community during monitoring by preventing potential exposure through the use of administrative controls and/or use of protective equipment. Ground water and air risks not addressed.	Not effective.	Dependent on natural attenuation and degradation.	Implementable	3.47
Alternative 2 Exposure control	Human health: No Air: No Ground water: Yes ^d Environment: No	Criterion may be met ^c	Protective of site workers and the community during remedial action by preventing potential exposure through the use of administrative controls and/or use of protective equipment. Addresses ground water risk with POU treatment at existing water-supply wells. Does not address air risk.	Effective for ground water risks at existing water-supply wells. Not effective for long-term reduction of VOC mass or air risk.	Dependent on natural attenuation and degradation.	Implementable	3.69
Alternative 3a Remediation and protection of the regional aquifer	Human health: Yes Air: Yes Ground water: Yes Environment: Yes	Criterion may be met	Protective of site workers and the community during remedial action by preventing potential exposure through the use of administrative controls and/or use of protective equipment. Addresses site risks with active remediation of soil and ground water.	Effective for air and ground water risks in the Tnbs ₁ aquifer. May not be effective for ground water risk in shallow aquifer in the central GSA. Ground water and soil vapor extraction increases source removal effectiveness.	Reduction in shallow unsaturated zone, and shallow and deep aquifer contamination; partially dependent on natural attenuation and degradation.	Implementable	17.17

Table 8. (Continued)

Alternative	Overall protection of human health and environment	Compliance with ARARs	Short-term effectiveness	Long-term effectiveness and permanence	Reduction in contaminant volume, toxicity, and mobility	Implementability	Cost ^{a,b}
Alternative 3b Ground water and soil remediation of both shallow and regional aquifers	Human health: Air: Yes Ground water: Yes Environment: Yes	Criterion met	Protective of site workers and the community during remedial action by preventing potential exposure through the use of administrative controls and/or use of protective equipment. Addresses site risks with active remediation of soil and ground water.	Effective for air and ground water risks. Ground water and soil vapor extraction address all soil and ground water contamination.	Reduction in shallow unsaturated zone, and shallow and deep aquifer contamination.	Implementable	18.90

^a Estimated total present worth in millions of 1995 dollars. Overall cost is highly dependent on the required length of pumping time.

^b The estimated costs for all alternatives presented in this ROD are slightly lower than the costs presented in the GSA FS and PP. This is due to modifications to the 1) contingency POU treatment component based on negotiations with the well owner, and 2) ground water monitoring component based on changes made to the eastern and central GSA treatment facility permit monitoring program requirements.

^c Relies solely on natural attenuation and degradation to comply with Safe Drinking Water Act, Basin Plan, and State Resolutions 68-16 and 92-49.

^d Protective of human health for ingestion of ground water from existing water-supply wells.

Table 9. Chemical-specific ARARs for potential chemicals of concern in ground water at the GSA OU.

Chemical of concern	Cancer group ^a	Federal MCL (µg/L)	State MCL (µg/L)
1,1,1-trichloroethane	D	200	200
1,1-dichloroethylene	C	7	6
cis-1,2-dichloroethylene	D	70	6
Benzene	A	5	1
Bromodichloromethane	B2	100 ^b	100 ^b
Chloroform	B2	100 ^b	100 ^b
Tetrachloroethylene	B2-C	5	5
Trichloroethylene	B2-C	5	5

^a Integrated Risk Information System (IRIS) database maintained by the U.S. EPA.

U.S. EPA cancer group:

A = Known carcinogen.

B2 = Probable carcinogen.

C = Possible carcinogen.

D = Noncarcinogen.

^b Total trihalomethanes.

NA = Not available.

µg/L = Micrograms per liter.

Table 10. Selected remedy (Alternative 3b): Capital costs for source mass removal and plume migration prevention in the GSA OU.

	Quantity	Unit type	Unit price (1995 \$)	Total (1995 \$)
Capital costs				
Central GSA				
Ground water and soil vapor extraction system				
major equipment costs (MEC)				
Wellhead vaults, valves, sampling ports, gauges	7 previously installed			
Additional wellhead vaults, valves, sampling ports, gauges	10	each	1,500	15,000
Electrical line and conduit	1,200	foot	1.75	2,100
2-in. polyvinyl chloride (PVC) piping	1,200	foot	1.50	1,800
Electric submersible pumps (1/2 horse power [hp])	10 previously installed			
Additional electric submersible pumps (1/2 hp)	10	each	800	8,000
PVC pipe fittings, unistrut	1	lot	10,000	10,000
SVE blower system (5 hp)	1	each	2,000	2,000
SVE pitot tubes, vacuum gauges, sampling ports	Previously installed			
SVE treatment MEC				
Moisture accumulation assembly, carbon canister hookup	Previously installed			
Vapor-phase carbon canisters (1,000 lb)	3	each	6,000	18,000
SVE manifold, piping	Previously installed			
Ground water treatment MEC				
Particulate filter assembly	1	each	3,700	3,700
Low-profile tray air stripper (includes blower and transfer pumps, total of 7 hp)	1	each	20,000	20,000
Carbon dioxide injection equipment	1	each	1,500	1,500
Discharge storage tank (20,000 gal.)	Previously installed			
Discharge pump (15 hp)	Previously installed			
Moisture accumulation assembly, carbon canister hookup	1	each	1,100	1,100
Air heater (700 W)	1	each	500	500
Vapor-phase carbon canisters (140 lb)	Previously installed			
Manifold, piping, valves, gauges, sampling ports, totalizer, controllers	1	lot	15,000	15,000
Discharge piping and fittings	Previously installed			
Total MEC for central GSA ground water and SVE treatment system				98,700
Eastern GSA				
Ground water extraction and treatment system				
MEC				
Wellhead vaults, valves, sampling ports, gauges	3 previously installed			
Electrical line and conduit	Previously installed			
Electric submersible pumps (1/2 hp)	3 previously installed			
2-in. PVC piping	Previously installed			
PVC pipe fittings, unistrut	Previously installed			
Particulate filter assembly	1	each	3,700	3,700
Low-profile tray air stripper (includes blower and transfer pumps, total of 7 hp)	1	each	20,000	20,000

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 \$)	Total (1995 \$)
Moisture accumulation assembly, carbon canister hookup	1	each	1,100	1,100
Vapor-phase carbon canisters (140 lb)		Previously installed		
Manifold, piping, valves, gauges, sampling ports, totalizer, controllers		Previously installed		
Discharge piping and fittings		Previously installed		
Total MEC for eastern GSA ground water treatment system				24,800
Total MEC for GSA ground water extraction and SVE treatment systems				123,500
Electrical components (20% of MEC)				24,700
Installation cost (58% of MEC)				71,630
Major equipment installed cost (MEIC)				219,830
Other capital costs				
Wells/borings				
Ground water extraction well installation and development	4	well	10,000	40,000
Piezometer installation and development	10	well	10,000	100,000
Soil boring and initial water sample analyses	14	well	1,500	21,000
Soil disposal (Class III)	35	cu yard	20	700
Hydraulic test for ground water extraction wells	10	well	3,000	30,000
Hydraulic test for reinjection well	1	well	5,000	5,000
Hydraulic test for piezometers	10	well	1,500	15,000
Structures				
Equipment building for central GSA SVE treatment system	1	each	300,000	300,000
Equipment building for central GSA ground water treatment system	1	each	300,000	300,000
Equipment building for eastern GSA ground water treatment system	1	each	300,000	300,000
Geotechnical testing	3	each	20,000	60,000
Contingency POU ground water treatment system for offsite water-supply wells CDF-1, CON-1, and SR-1				
Wellhead modification	3	each	1,000	3,000
Particulate filter	3	each	2,000	6,000
Aqueous-phase carbon beds (1,000 lb)	6	each	6,000	36,000
Double-containment skid (8' x 15')	3	each	4,000	12,000
System plumbing, totalizer, fittings	3	lot	2,000	6,000
Total field costs (TFC)				1,454,530
Professional environmental services				
Design/assist with project management				50,000
Permitting				50,000
Start-up labor and analyses				60,000
SVE performance evaluation				25,000
Total professional environmental services				185,000
LLNL tax (11% of total field costs and professional environmental services)				180,348

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 \$)	Total (1995 \$)
LLNL Environmental Restoration Division (ERD) team				
Full-time employee (FTE)	3	FTE	180,000	540,000
Remedial Design Report				300,000
Total LLNL ERD team				840,000
LLNL technical support services				
LLNL Plant Engineering planning and Title I, II, and III services	5	FTE	180,000	900,000
Total LLNL support services				900,000
Total capital costs				3,559,878
Operation and maintenance (O&M) costs				
Fixed O&M costs for soil vapor and ground water extraction and treatment				
Fixed annual O&M costs for SVE				
Electricity	30,000	kw¥h	0.07	2,100
Electrical capacity charge	3.7	kw	36	133
SVE air sampling analysis	12	event	560	6,720
Maintenance materials (10% of total installed MEC)				8,200
LLNL tax (11% of outside charges)				1,887
Project management	0.15	FTE	238,500	35,775
System optimization, engineer	0.20	FTE	173,500	34,700
Well field optimization, hydrogeologist	0.10	FTE	173,500	17,350
Operating labor	0.30	FTE	129,800	38,940
Clerical	0.10	FTE	92,600	9,260
Maintenance labor (15% of total installation cost)				7,134
Total fixed annual SVE O&M costs				162,199
Total present worth of fixed O&M for soil vapor extraction, years 1–10 (factor = 8.317)				1,349,010
Fixed annual ground water extraction and treatment O&M for central GSA				
Electricity	170,000	kw¥h	0.07	11,900
Electrical capacity charge	21.6	kw	36	776
Scale prevention/recarbonation	4,000	lb CO2	0.60	2,400
Ground water treatment system air sampling analysis	12	event	560	6,720
Ground water treatment system analyses (water only)	12	event	200	2,400
Maintenance materials (10% of total installed MEC)				16,300
LLNL tax (11% of outside charges)				4,455
Project management	0.10	FTE	238,500	23,850
System optimization, engineer	0.15	FTE	173,500	26,025
Well field optimization, hydrogeologist	0.15	FTE	173,500	26,025
Operating labor	0.30	FTE	129,800	38,940
Clerical	0.10	FTE	92,600	9,260

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 \$)	Total (1995 \$)
Maintenance labor (15% of total installation cost)				14,181
Total fixed annual ground water extraction and treatment O&M for central GSA				183,232
Total present worth of annual ground water treatment O&M for central GSA, years 1-55 (factor = 24.264)				4,445,937
Fixed annual ground water extraction and treatment O&M for eastern GSA				
Electricity	60,000	kw¥h	0.07	4,200
Electrical capacity charge	7.6	kw	36	274
Scale prevention/recarbonation	12,000	lb CO2	0.60	7,200
Ground water treatment system air sampling analysis	12	event	560	6,720
Ground water treatment system analyses (water only)	12	event	200	2,400
Maintenance materials (10% of total installed MEC)				10,000
LLNL tax (11% of outside charges)				3,387
Project management	0.10	FTE	238,500	23,850
System optimization, engineer	0.15	FTE	173,500	26,025
Well field optimization, hydrogeologist	0.15	FTE	173,500	26,025
Operating labor	0.30	FTE	129,800	38,940
Clerical	0.10	FTE	92,600	9,260
Maintenance labor (15% of total installation cost)				8,700
Total fixed annual ground water extraction and treatment O&M for eastern GSA				166,981
Total present worth of annual ground water treatment O&M for eastern GSA, years 1-10 (factor = 8.327)				1,390,453
Total present worth of fixed O&M costs for 55 years				7,185,400
Variable operating costs for soil vapor and ground water extraction and treatment				
Annual costs, year 1				
SVE replacement of GAC	3,950	lb	2.30	9,085
Ground water treatment system replacement of vapor phase GAC	650	lb	2.30	1,495
Total annual costs, year 1				10,580
Total present worth, year 1 (factor = 0.966)				10,220
Annual costs, year 2				
SVE replacement of GAC	980	lb	2.30	2,254
Ground water treatment system replacement of vapor phase GAC	650	lb	2.30	1,495
Total annual costs, year 2				3,749
Total present worth, year 2 (factor = 0.934)				3,502

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 \$)	Total (1995 \$)
Annual costs, year 3				
SVE replacement of GAC	490	lb	2.30	1,127
Ground water treatment system replacement of vapor phase GAC	650	lb	2.30	1,495
Total annual costs, year 3				2,622
Total present worth, year 3 (factor = 0.902)				2,365
Annual costs, year 4				
SVE replacement of GAC	125	lb	2.30	288
Ground water treatment system replacement of vapor phase GAC	650	lb	2.30	1,495
Total annual costs, year 4				1,783
Total present worth, year 4 (factor = 0.871)				1,553
Annual costs, year 5				
SVE replacement of GAC	60	lb	2.30	138
Ground water treatment system replacement of vapor GAC	650	lb	2.30	1,495
Total annual costs, year 5				1,633
Total present worth, year 5 (factor = 0.842)				1,375
Annual costs, years 6-10				
SVE replacement of GAC	5	lb	2.30	12
Ground water treatment system replacement of vapor phase GAC	325	lb	2.30	748
Total annual costs, years 6-10				759
Total present worth, years 6-10 (factor = 3.801)				2,885
Annual costs, years 11-30				
Ground water treatment system replacement of vapor phase GAC	75	lb	2.30	173
Total annual costs, years 11-30				173
Total present worth, years 11-30 (factor = 10.075)				1,738
Annual costs, years 31-55				
Ground water treatment system replacement of vapor phase GAC	5	lb	2.30	12
Total annual costs, years 31-55				12
Total present worth, years 31-55 (factor = 5.872)				68
Total present worth of variable operating costs for soil vapor and ground water extraction and treatment				23,705
Ground water and soil vapor monitoring				
Annual costs, years 1-10				
SVE vapor VOC analysis	84	each	110	9,240
VOC analysis (EPA Method 601)	206	each	50	10,300
VOC analysis (EPA Method 602)	12	each	50	600
Annual spring water sample analyses	3	suite	545	1,635
QA/QC analyses (10% of analytic costs)				2,178
Quarterly monitoring reports	4	report	15,000	60,000

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 \$)	Total (1995 \$)
LLNL tax (11% of outside charges)				9,235
Monthly SVE vapor sample collection	7	well	375	2,625
Quarterly water level measurements (including 10 piezometers)	111	well	62.50	6,938
Quarterly ground water sample collection	7	well	500	3,500
Semiannual ground water sample collection	89	well	250	22,250
Annual ground water sample collection	12	well	125	1,500
Annual spring water sample collection	3	spring	125	375
Maintenance of ground water sampling system	101	well	430	43,430
Project management	0.35	FTE	238,500	83,475
Total annual costs, years 1-10				257,280
Total present worth, years 1-10 years (factor = 8.317)				2,139,796
Annual costs, years 11-55				
VOC analysis (EPA Method 8010)	128	each	50	6,400
VOC analysis (EPA Method 8020)	12	each	50	600
Annual spring water sample analyses	3	suite	545	1,635
QA/QC analyses (10% of analytic costs)				864
Annual monitoring report	1	report	15,000	15,000
LLNL tax (11% of outside charges)				2,695
Quarterly water level measurements (including 10 piezometers)	111	well	62.50	6,938
Semiannual ground water sample collection	39	well	250	9,750
Annual ground water sample collection	50	well	125	6,250
Annual spring water sample collection	3	spring	125	375
Maintenance of ground water sampling system	91	well	430	39,130
Project management	0.35	FTE	238,500	83,475
Total annual costs, years 11-55				173,111
Total present worth, years 11-55 years (factor=15.947)				2,760,598
Annual costs, years 56-60				
VOC analysis (EPA Method 601)	111	each	50	5,550
VOC analysis (EPA Method 602)	12	each	50	600
Annual spring water sample analyses	3	suite	545	1,635
QA/QC analyses (10% of analytic costs)				779
Annual monitoring report	1	report	15,000	15,000
LLNL tax (11% of outside charges)				2,592
Quarterly water level measurements (including 10 piezometers)	111	well	62.50	6,938
Semiannual ground water sample collection	37	well	250	9,250
Annual ground water sample collection	37	well	125	4,625
Annual spring water sample collection	3	spring	125	375
Maintenance of ground water sampling system	74	well	430	31,820
Project management	0.15	FTE	238,500	35,775
Total annual costs, years 56-60				114,938
Total present worth, years 56-60 years (factor = 0.681)				78,273

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 \$)	Total (1995 \$)
Total present worth of ground water and soil vapor monitoring for 60 years (5 years after reaching MCLs)				4,978,667
Contingency costs and totals				
Subtotal present worth of Alternative 3b				15,747,651
Contingency (20%)				3,149,530
Total present worth of Alternative 3b				18,897,181

Table 11. ARARs for the selected remedy at the GSA OU.

Action	Source	Description	Application to the selected remedy
Ground water extraction	Federal: Safe Drinking Water Act [42 USCA 300 and 40 CFR 141.11-141.16, 141.50-141.51] (Applicable: Chemical-specific)	Establishes treatment standards for current potential drinking water sources by setting MCLs and non-zero Maximum Contaminant Level Goals (MCLGs), which are used as cleanup standards. Those standards for the GSA OU are listed in Table 9 of the ROD.	As part of the selected remedy, VOC concentrations will be reduced to MCLs in all ground water in the GSA OU.
	State: State Water Resources Control Board (SWRCB) Resolution 92-49 (Applicable: Chemical-specific)	Requires oversight of investigations and cleanup and abatement activities resulting from discharges of waste that affect or threaten water quality.	All cleanup activities associated with implementation of the selected remedy will be conducted under the supervision of the CVRWQCB.
	Cal. Safe Drinking Water [California Health and Safety Code Section 116365] (Applicable: Chemical-specific)	Establishes treatment standards for current potential drinking water sources by setting MCLs which are used as cleanup standards. Those standards for the GSA OU are listed in Table 9 of the ROD.	As part of the selected remedy, concentrations will be reduced to MCLs in all ground water in the GSA OU.
	Chapter 15, Code of California Regulations (CCR), Title 23, Sections 2550.7, 2550.10 (Applicable: Chemical-specific)	Requires monitoring of the effectiveness of the remedial actions.	During and after completion of the selected remedy, concentrations of VOCs in <i>in situ</i> ground water will be measured.

Table 11. (Continued)

Action	Source	Description	Application to the selected remedy
Ground water extraction (cont.)	<i>State: (cont.)</i>		
	Water Quality Control Plan (Basin Plan) for CVRWQCB (Applicable: Chemical-specific)	Establishes beneficial uses and water quality objectives for ground water and surface waters in the Central Valley Region as well as implementation plans to meet water quality objectives and protect beneficial uses.	As part of the selected remedy, VOC concentrations in ground water will be remediated to levels listed in Table 9.
	SWRCB Resolution 88-63 (Applicable: Chemical-specific)	Designates all ground and surface waters in the State as drinking water sources with specific exceptions.	As part of the selected remedy, VOC concentrations will be reduced to levels protective of drinking water beneficial use as described in Section 2.10.1.
Soil vapor extraction	<i>State:</i>		
	Water Quality Control Plan (Basin Plan) for CVRWQCB (Applicable: Chemical-specific)	Establishes beneficial uses and water quality objectives for ground water and surface waters in the Central Valley Region, as well as implementation plans to meet water quality objectives and protect beneficial uses.	As part of the selected remedy, VOC concentrations in soil vapor will be remediated to levels protective of ground water (MCLs).
	Chapter 15, CCR, Title 23, Sections 2550.7, 2550.10 (Applicable: Chemical-specific)	Requires monitoring of the effectiveness of the remedial actions.	During and after completion of the selected remedy, concentrations of contaminants in <i>in situ</i> soil vapor will be measured.

Table 11. (Continued)

Action	Source	Description	Application to the selected remedy
<p>Contingency POU treatment at water-supply wells</p>	<p>State: Cal. Safe Drinking Water Act (California Health and Safety Code Section 116365) (Applicable: Chemical-specific)</p>	<p>Establishes chemical-specific standards for public drinking water systems by setting MCL goals.</p>	<p>As part of the selected remedy, VOC concentrations will be reduced to MCLs by POU treatment at existing water-supply wells, if necessary.</p>
	<p>SWRCB Resolution 92-49 (Applicable: Chemical-specific)</p>	<p>Requires oversight of investigations and cleanup and abatement activities resulting from discharges of waste that affect or threaten water quality.</p>	<p>All cleanup activities associated with implementation of the selected remedy will be conducted with oversight by the CVRWQCB.</p>
<p>Treated ground water discharge</p>	<p>State: SWRCB Resolution 68-16 (Anti-degradation policy) (Applicable: Chemical-specific)</p>	<p>Requires that high quality surface and ground water be maintained to the maximum extent possible.</p>	<p>In the context of the selected remedy, this is applicable to the discharges of treated ground water. The eastern GSA ground water treatment system (GWTS) discharges treated water to Corral Hollow Creek under the requirements of the current NPDES permit issued by the CVRWQCB. The central GSA GWTS discharges to bedrock in an onsite canyon under the requirements of the current Substantive Requirements issued by the CVRWQCB.</p>

Table 11. (Continued)

Action	Source	Description	Application to the selected remedy
<p>Treated ground water reinjection</p>	<p><i>Federal:</i> Safe Drinking Water Act Underground Injection Control Program (40 CFR 144.26-124.27) (Applicable: Action-specific) SWRCB Resolution 68-16 (Anti- degradation policy) (Applicable: Chemical-specific)</p>	<p>Requires monitoring for reinjection of treated water.</p> <p>Requires that high quality surface and ground water be maintained to the maximum extent possible.</p>	<p>During the selected remedy, treated ground water would be analyzed to verify complete removal of VOCs to regulatory treatment standards, prior to reinjection.</p>
<p>Treated soil vapor discharge</p>	<p><i>Local:</i> San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) Rules and Regulations, Rules 463.5 and 2201 (Applicable: Chemical-specific)</p>	<p>Regulates nonvehicular sources of air contaminants.</p>	<p>During the selected remedy, contaminated soil vapor will be treated with GAC, or equivalent technologies, and discharged to the atmosphere. The compliance standards for treated soil vapor are contained in the current Authority to Construct and subsequent Permit to Operate issued by the SJVUAPCD.</p>
<p>Disposition of hazardous waste</p>	<p><i>State:</i> Health and Safety Code, Sections 25100-25395, CCR, Title 22, Ch. 30: Minimum Standards for Management of Hazardous and Extremely Hazardous Wastes (Applicable: Action-specific)</p>	<p>Controls hazardous wastes from point of generation through accumulation, transportation, treatment, storage, and ultimate disposal.</p>	<p>For the selected remedy, this ARAR applies primarily to the spent GAC vessels.</p>

Table 11. (Continued)

Action	Source	Description	Application to the selected remedy
Protection of endangered species	<p><i>Federal:</i> Endangered Species Act of 1973, 16 USC Section 1531 et seq. 50 CFR Part 200, 50 CFR Part 402 [40 CFR 257.3-2] (Applicable: Location-specific)</p> <p><i>State:</i> California Endangered Species Act, California Department of Fish and Game Sections 2050-2068 (Applicable: Location-specific)</p>	<p>Requires that facilities or practices not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife. NEPA implementation requirements may apply.</p>	<p>Prior to any well installation, facility construction, or similar potentially disruptive activities, wildlife surveys will be conducted and mitigation measures implemented if required.</p>
Floodplain protection	<p><i>State:</i> 22 CCR 66264.18 (B)(1) (Applicable: Location-specific)</p>	<p>Requires that TSD facilities within a 100-year floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood.</p>	<p>If it becomes necessary to install point-of-use treatment for water-supply wells CDF-1 or CON-1, which are located offsite within the 100-year floodplain, the POU systems would be constructed in accordance with this requirement.</p>

Acronyms and Abbreviations

Acronyms and Abbreviations

AOS	Adult Onsite
ARARs	Applicable or Relevant and Appropriate Requirements
Cal EPA	State of California, Environmental Protection Agency
CARE	Citizens Against a Radioactive Environment
CCR	Code of California Regulations
CDF	California Department of Forestry
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CMB	Claystone Marker Bed
CPF	Cancer Potency Factor
CVRWQCB	Central Valley Regional Water Quality Control Board
DCE	Dichloroethylene
DNAPLs	Dense Nonaqueous Phase Liquids
DOE	Department of Energy
DTSC	California Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
ERD	Environmental Restoration Division
FFA	Federal Facility Agreement
FS	Feasibility Study
FTE	Full Time Employee
GAC	Granular Activated Carbon
gal	Gallons
gpm	Gallons per minute
GSA	General Services Area
GWTS	Ground Water Treatment System
HE	High Explosives
HI	Hazard Index
hp	Horsepower
HQ	Hazard Quotient
HMX	Cyclotetramethylenetetranitramine
IRIS	Integrated Risk Information System

LLNL	Lawrence Livermore National Laboratory
MCLs	Maximum Contaminant Levels
MEC	Major Equipment Cost
MEIC	Major Equipment Installed Cost
mg/kg	Milligrams per kilogram
mg/L	Micrograms per liter
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PCE	Tetrachloroethylene
PEFs	Pathway Exposure Factors
POU	Point of Use
ppb _{v/v}	Parts per billion on a volume-to-volume basis. Also referred to as ppb _v .
PRGs	Preliminary Remediation Goals
PVC	Polyvinyl Chloride
QA	Quality Assurance
Qal	Quaternary alluvial deposits
QC	Quality Control
Qt	Quaternary terrace deposits
RAOs	Remedial Action Objectives
RES	Residential Exposure
RfD	Reference Dose
ROD	Record of Decision
RWQCB	California Regional Water Quality Control Board
SARA	Superfund Amendments and Reauthorization Act of 1986
SJVUAPCD	San Joaquin Valley Unified Air Pollution Control District
SVE	Soil Vapor Extraction
SWRCB	State Water Resource Control Board
SWRI	Site Wide Remedial Investigation
TCE	Trichloroethylene
TFC	Total Field Cost
Tmss	Miocene Cierbo Formation
Tnbs ₁	Miocene Neroly Formation - Lower Blue Sandstone Member

Tnbs ₂	Miocene Neroly Formation - Upper Blue Sandstone Member
Tnsc ₁	Miocene Neroly Formation - Middle Siltstone/Claystone Member
UCRL	University of California Radiation Laboratory
UCL	Upper Confidence Limit
VOCs	Volatile Organic Compounds